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CONTENTS

(*Continued on cover page* 4)

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Entomon 1991 Vol. 16 No. 4 pp 251 to 255

EFFECT OF ENDOCRINE EXTRACTS ON THE BLOOD VOLUME AND POPULATION OF HAEMOCYTES IN *HALYS DENTATA* (PENTATOMIDAE - HETEROPTERA)

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(*Received* 23 *September* 1990)

It has been observed that in *Halys dentata* diuretic hormone present in the extract of brain and corpora cardiaca of well fed six-day-old adults could decrease blood volume; hence the total haemocyte counts (THC) increased. But there was no effect on differential haemocyte counts (DHC) and absolute number of circulating cells. Similarly the antidiuretic hormone present in the thoracoabdominal ganglion of unfed adults increases the blood volume which causes significant decrease in THC. In this case also there was no significant change in DHC and absolute number of circulating cells. The corpora allata extract (juvenile hormone) which has no effect on the blood volume could influence the total haemocyte counts, and absolute number of circulating haemocytes. Therefore, it was concluded that juvenile hormone is capable of inducing the sessile haemocytes to reach in circulation.

(*Key words*: haemogram, endocrine glands, corpora allata, corpora cardiaca, diuretic and antidiuretic hormones, brain, juvenile hormone)

INTRODUCTION

In insects the interrelationship between hormones and haemogram is still comparatively little known. However, circumstancial evidence has been gathered in favour of interrelationship of endocrine glands and insect haemogram (JONES & LIU 1969; HOFFMANN 1970; PATHAK, 1983, 1986). WEBLEY (1951), NITTONO (1960), WHEELER (1963), and FEIR (1979) are of the opinion that any loss or gain in volume of water in the haemolymph may affect the total haemocyte counts of insect but might not affect the absolute number of haemocytes. In *Halys denata* neurosecretory cells of pars-intercerebralis of brain release diuretic hormone in well fed hydrated insects which reaches the haemolymph through corpora cardiaca in 6 day-old adult insect. The antidiuretic hormone is released from the neurosecretory cells of thoracoabdominal ganglionic mass and is predominant in unfed dehydrated insects. The corpora allata have neither diuretic nor antidiuretic hormone (PATHAK, 1989). The diuretic hormone accelerates the rate of excretion, hence it reduces the haemolymph volume. The antidiuretic hormone decelerates the rate of excretion and thus increases the blood volume. So it was thought that there was a direct relationship among hormones, blood volume and the population of haemocytes. The present study is an attempt to trace a correlation between the extracts to various endocrine glands, blood volume, THC, DHC and absolute circulating haemocytes in 6-day-old well fed adult *Halys dentata*.

MATERIALS AND METHODS

Rearing of insects: Insects were reared in the laboratory at 27° ± 1°C and relative humidity of 70 to 80%. They were fed on wet tamarind plant bark and green twigs. The bark paste with 2% (W/W) glucose was also made available to them.

All the recipient insects were 6-day-old, well-fed adults, their weight varied from 678 mg to 805 mg. In each study 20 insects of both the sexes were used.

Preparation of extract: Extracts of various endocrine glands were prepared by sonication and homogenising 20 brains, corpora cardiaca, corpora allata or thoracoabdominal ganglionic mass in one ml of Ringer's solution from the group of hydrated (well-fed), and dehydrated (deprived of food and water for 72 h) six-day-old adults. Homogenised tissues were centrifuged at 5000 *g* for 1 h and supernatant was considered as fraction-I. The residue was rehomogenised and centrifuged with methanol for 1 h at 4°C. The supernatant was fraction–II. Both the fractions were lyophilized and then redissolved in 100 μl of normal saline and methanol separately and mixed prior to injection in experimental insects. For controls muscle extract was prepared in the same manner. The extract was injected in recipient at 50 μl per gram body weight.

Determination of blood volume: Five batches of 10 insects were used for each study of blood volume. The extract of particular endocrine gland was first injected in the insects and they were kept for 4 h in the cage without food and water. After 4 h, 50 ml of 1% amaranth red dye in Ringer solution was injected in each insect and was allowed to circulate for 3–5 minutes. 100 μl blood was collected from each insect and pooled. A few crystals of phenylthiourea were added to avoid melanization. The collected blood was centrifuged at 1000 *g* for 10 minutes at 4°C. The absorbance of blood samples and standards were determined with digital double beam spectrophotometer uv/50 (Shimadzu-Japan) at 515 nm and blood volume was determined by the formula suggested by SHAPIRO (1979). In the present study the data of blood volume represents the mean blood volume of 50 insects.

Counting of haemocytes: The total haemocyte counts (THC) were made on different batches of 6-day-old well-fed adults. The extracts of various endocrine glands of hydrated and dehydrated insects were injected and insects were kept in cages for 4 h without food and water. Only a single withdrawal was made from each individual. Blood from adult insect was collected on a glass slide and quickly drawn into a Thoma white blood cell diluting pipette with physiological saline (ROSENBERGER & JONES, 1960). After shaking vigorously and discarding the first 3 drops (JONES, 1962), the haemolymph was transferred to a Neubauer double-lined haemocytometer and cells were counted in 5 mm ruled squares. In each case, three readings were taken from diluted haemolymph and their average was used as the final reading. The differential haemocyte counts (DHC) were made to determine the different circulating haemocytes. The blood smears stained with Giemsa-stain were observed under oil immersion, and 200 cells per slide were differentiated. In all 20 different slides were observed in each stage.

The absolute number of circulating haemocytes was calculated by multiplying mean THC with mean blood volume (WHEELER, 1963). The absolute number of different circulating haemocytes was calculated from the total number of circulating cells on the basis of their percentage i. e., differential haemocyte counts.

Student's 't' test was applied for satistical analysis and means different at alpha = 0.05 were considered to be significantly different.

OBSERVATIONS

Studies on the haemolymph volume and unfixed total haemocyte counts:

The haemolymph volume of 6-day-old well-fed adults was determined after injecting the extracts of various endocrine glands of hydrated and dehydrated insects. When brain and corpora cardiaca extracts of hydrated, well-fed, 6-day-old adult insects were injected the blood volume of recipients decreased significantly ($P < 0.05$) in comparison to control (Table 1). There was no significant difference in the blood volume of recipients of corpora allata/ thoracoabdominal ganglionic mass extracts of hydrated insects (Table 1).

When the endocrine extracts prepared from dehydrated insects were used, it was found that the brain, corpora cardiaca and corpora allata extracts could not influence the blood volume while the extract of thoracoabdominal ganglionic mass could increase (Table 1) the blood volume significantly ($P < 0.05$).

The unfixed total haemocyte counts were determined in 6-day old well fed insects after injecting the extracts of various endo crine glands of hydrated and dehydrated insects. The recipients of brain and corpora cardiaca extracts of hydrated insects have shown significantly higher THC after 4 h post injection. The extract of thoracoabdominal ganglion has no significant impact on THC. In case where the extract of dehydrated insects were used, brain and corpora cardiaca extracts could not influence the THC (Table 1); however, THC

TABLE 1. Total haemocyte counts (Mean ± SD) in mm^3 and blood volume (in μl) in 6 day-old adult *Halys dentata* after 4 h post injection of endocrine extracts.

Extract injected	Total haemocyte counts (THC) (Mean ± SD) (n = 20)	Mean blood volume (μl) (n = 50)	Absolute no. of haemocytes THC × B V
A. *Hydrated insects*			
i. Brain	15921 ± 1263*	70.53 ± 2.31*	1122908
ii. Corpora cardiaca	15302 ± 1058*	71.65 ± 3.28*	1096388
iii. Corpora allata	16906 ± 1987*	79.56 ± 1.26	1345041
iv. Thoracoabdominal ganglion	13298 ± 1082	80.09 ± 1.37	1065037
B. *Dehydrated insects*			
i. Brain	13388 ± 1023	79.12 ± 2.24	1059258
ii. Corpora cardiaca	13546 ± 1124	78.23 ± 1.22	1059703
iii. Corpora allata	16278 ± 1835*	79.04 ± 2.37	1286613
iv. Thoracoabdominal ganglion	11897 ± 980*	89.79 ± 3.45*	1068231
v. Control (muscle ex.)	13908 ± 1164	80.18 ± 1.34	1115143

*Readings are significantly higher or lower than the control.

decreased when the extract of thoracoabdominal ganglionic mass was injected. The recipients of corpora allata extract from hydrated or dehydrated insects have shown significant increase in total haemocyte counts after 4 h post-injection though there was no change in the blood volume.

Studies on differential haemocyte counts and absolute number of circulating cells:

On the basis of classification suggested by JONES (1962) in *Halys dentata* five types of haemocytes were found i.e., prohaemocytes, plasmatocytes, granuler cells, oenocytoids and adipohaemocytes. Out of them the plasmatocytes and granular cells were the main circulating haemocytes. The recipients of different endocrine extracts have not shown any significant change in DHC in comparison to control (Table 2). The calculations in Table 1 indicate that the absolute number of circulating haemocytes significantly increased in the recipients of corpora allata extract. The highest increase was noted in plasmatocytes and granular cells (Table 2). Therefore, it was concluded that probably non circulating sessile haemocyte population was mobilized by corpora allata extract to enhance THC and absolute number of circulating cells.

DISCUSSION

The interrelationship between blood volume and haemogram was advocated by number of workers. NITTONO (1960) studied the total haemocyte counts of different races of *B. mori* and felt that increase in THC was attributed to an actual increase of circulating haemocytes as well as to a reduction of blood volume. The changes in the counts of haemocytes are synchronized with the physiological conditions of the insect. Hormones directly or indirectly influence the blood volume, therefore, affecting the haemocyte counts (FEIR, 1979; PATHAK, 1983, 1986). FEIR (1979) described that any loss or gain in volume of water in the haemolymph may affect the total haemocyte counts of the

TABLE 2. Effect of injection of various endocrine extracts on the mean differential counts (% ± S D) of well fed 6-day-old adult (n = 20).

Haemocytes	Brain extract (hydrated)	Corpora cardiaca extract (hydrated)	Corpora allata extract (hydrated)	Thoracoabdominal ganglion extract (dehydrated)	Control
Prohaemocytes	4.0 ± 0.33 (44916)*	3.9 ± 0.32 (42759)	3.7 ± .41 (49766)	4.1 ± .62 (43995)	4.0 ± .38 (44606)
Plasmatocytes	44.0 ± 7.28 (494079)	45.0 ± 7.72 (493375)	46.5 ± 7.93 (625444)	45.6 ± 7.23 (489309)	44.6 ± 7.37 (497354)
Granular cell	36.9 ± 4.41 (414353)	36.6 ± 4.92 (401278)	36.3 ± 5.23 (488250)	36.4 ± 3.87 (390588)	37.2 ± 3.82 (4148331)
Oenocytoids	8.7 ± 1.62 (97693)	8.6 ± 1.43 (94289)	8.5 ± 1.37 (114328)	8.5 ± 1.29 (91209)	8.6 ± 1.35 (959021)
Adipohaemocytes	5.8 ± 1.48 (65129)	5.9 ± 1.53 (64687)	5.0 ± 1.76 (67252)	5.4 ± 1.62 (57944)	5.6 ± 1.64 (624481)

*Number in perentheses represents the calculated number of different circulating haemocytes.

insect, but might not have any effect on the absolute number of circulating cells. WHEELER (1963) has demonstrated that an increase in blood volume in *Periplaneta americana* decreases the total haemocyte counts and counts may increase with the loss of blood volume.

In the light of recent studies (PATHAK, 1989) it was inferred that in *Halys dentata* brain and corpora cardiaca extracts of hydrated 6-day-old adults were able to decrease the blood volume due to the presence of diuretic hormone. Therefore, THC increased while the extract of thoracoabdominal ganglionic mass of dehydrated insect possesses predominant antidiuretic hormone which increases the blood volume to reduce the total haemocyte counts of recipients.

In *Halys dentata* the THC and the number of absolute circulating cells increased significantly by corpora allata extract of both hydrated and dehydrated insects though it has no effect on the blood volume. Therefore, it was concluded that an increase or decrease in the THC is not merely reflection of a decrease or increase in the blood volume. Probably in *Halys dentata* the injection of corpora allata extract or juvenile hormone has some impact on the physiological status of the insect which in turn stimulates the non-circulating haemocytes to reach circulation to enhance the THC and absolute circulating haemocytes or sessile haemocytes were induced by higher juveline hormone titer for some specific function to reach circulation.

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Entomon 1991 Vol. 16 No. 4 pp. 257 to 260

TESTICULAR DEGENERATION IN *DYSDERCUS KOENIGII* AFTER MICROWAVE EXPOSURE

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(*Received* 28 *October* 1990)

Histological changes in the testes of adult *Dysdercus koenigii* have been observed after exposing them to microwave. These changes are in the form of reduction in size of the cell and nucleus of spermatogonia and spermatocytes. Pycnosis of the nuclei of both spermatogonia and spermatocytes has been observed. Hypertrophy and dissociation of spermatozoa have also been observed. The damage in the testes increases with the exposure time. The changes in the testes may be due to thermal and non-thermal effects of microwaves.

(*Key words:* microwave, pycnosis, hypertrophy, thermal and non-thermal effects)

INTRODUCTION

Most of the effects of microwaves are due to their thermal effects. Damage to various structures and tissues have been reported after exposing them to microwaves (CARPENTER & LIVESTONE, 1971; ZDAREK *et al.*, 1976; ONDRACEK, 1977). The alterations which occur due to microwave exposures are malformation of appendages, cuticle, atrophy and abnormal development of internal organs etc. Differential susceptibility of tissues to microwaves has been reported by ZDAREK *et al.* (1976). Adults emerging from microwave exposed pupae of *Tenebrio molitor* show morphological damages (CARPENTER & LIVESTONE, 1971). Dielectric properties of different tissues have been measured after exposing to microwaves (ONDRACEK & BRUNNHOFER, 1984). Microwaves cause formation of hot spots in biological systems excluding small organisms and isects. The aim of the present study is to explore cytological effects, if any, on the testes of *Dysdercus koenigii*, when exposed to microwaves.

*Correspondent author.

MATERIALS & METHODS

A colony of *Dysdercus koenigii* was raised from a single pair of adults collected from Agriculture Research Centre Tabiji, Ajmer. The colony was maintained at 28° ± 2°C. The insects were reared in glass jars and fed with soaked cotton seeds. Eggs were collected and developed in petri-dishes.

Adults (males) after second day of their emergence were collected and exposed to microwaves. Klystron oscillator was used as a source of microwaves. An electronically regulated power supply was used to feed the Klystron oscillator. Frequency of microwaves was measured by using a tunable frequency meter. During the present study frequency was maintained at 9.86 Ghz with 10 mw power supply. Radiation dose was always kept constant using an attenuator. Testes from insects exposed for 2, 4, 6, 8, and 10 h were taken out under binocular microscope and immediately fixed in Bouin's fluid and sections were cut at 7μm. Slides were stained in haemotoxylin-eosin.

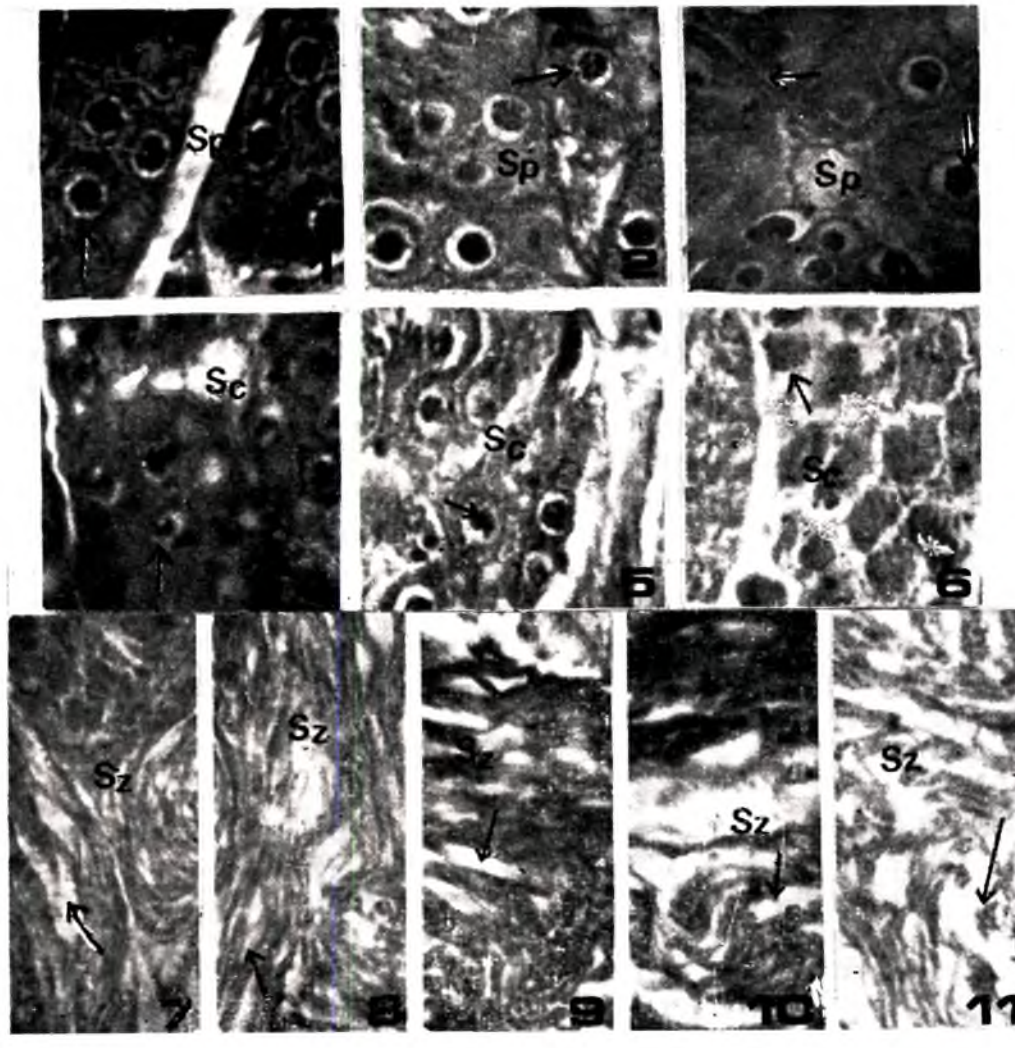

Fig. 1. L. S. Normal testis, × 400, showing spermatogonia (arrow); Fig. 2. L. S. 8 h exposed testis × 400, showing pycnotic nuclei (arrow 1) and thickened follicular margins (arrow 2); Fig. 3. L. S. 10 h exposed testis × 400, showing necrotic spermatogonia; Fig. 4. L. S. Normal testis × 400 showing spermatocytes; Fig. 5. L. S. 6 h exposed, × 400, showing spermatocytes and degenerating connective tissue; Fig. 6. L. S. 10 h exposed × 400, spermatocytes showing necrosis of connective tissue; Fig. 7. L. S. Normal testis × 400, showing spermatozoa; Fig. 8. L. S. 4 h exposed testis × 400 showing spermatozoa scattered from bundles and heads clumping; Fig. 9. L. S. 6 h exposed testis, × 400 showing spermatozoa scattered from bundles; Fig. 10 L. S. 8 h exposed testis × 400, showing spermatozoa heads clumped and tails broken. Fig. 11. L. S. 10 h exposed testis × 400, showing hypertrophied spermatozoa.

Abbreviations used

Sp—spermatogonia; Sc—spermatocytes; Sz—spermatozoa.

RESULT AND DISCUSSION

The follicle of testis contains a succession of zones, as has been recorded in *Chrysocoris stollii* (Pentatomidae) by DEB *et al.* 1983), in which sex cells in different stages of development are found. The first zone contains spermatogonia which have distinct nuclei. The second zone has spermatocytes (Fig. 4). In the last zone spermatozoa are present in bundles.

Effects of Exposure: Two h of exposure: Both spermatogonia and spermatocytes show increase in size. This increase is being observed both in cell and nucleus. However, there is no effect on the spermatozoa.

Four hour of exposure: Both spermatogonia and spermatocytes show decrease in size. This may be due tc heating effect of microwaves. Water contents of the cell start decreasing and cell body starts shrinking. At this stage spermatozoa began to get scattered from the bundles (Fig. 8).

Six hour of exposure: There is further reduction in cell size and nuclear size (Table 1). Nuclei show pycnosis both in spermatogonia and spermatocytes. The sperm bundles are broken and spermatozoa scattered (Fig. 9). The connecting tissue around the germ cells also starts breaking down (Fig. 5).

Eight hour of exposure: The germinal cells have reduced greatly in size. Spermatogonial nuclei show severe pycnosis (Fig. 2). The follicular margins appeared thickened. Spermatozoa heads show clumping (Fig. 10) and have lost their tails and they lie scattered.

Ten hour of treatment: Complete destruction of follicular tissue. Nuclei of the spermatogonia start degenerating and their cytoplasam contracts (Fig. 3). The connective tissue shows further necrosis (Fig. 6). The spermatozoa become hypertrophied and get scattered (Fig. 11).

The visible damage to the male gonads are nuclear pycnosis, reduction in size and disintegration of germ cells. The spermatozoa are hypertrophied and scattered in the lumen. The hypertrophied state may cause the loss of motility of sperms. Follicular margin show thickening. The increase in size of spermatocytes and spermatogonia at 2 h exposure is non signi-

TABLE 1. Reduction in size of cells* and nuclei* after microwave exposures for vaious hours.

Hour after treatment	Spermatogonia		Spermatocytes	
	Cell size in μm	Nuclear size in μm	Cell size in μm	Nuclear size in μm
Normal	12.00	5.50	14.25	10.15
2	12.50	6.15	15.00	12.00
4	11.25	6.00	14.75	10.50
6	9.75	5.25	13.50	9.25
8	9.00	5.00	12.50	9.00
10	7.50	4.50	11.25	7.50

* Mean of 10 observations.

ficant but this is significant ($P<0.001$) at longer exposures which cause gradual decrease in the size of cell and nucleus.

Besides morphological damage and deranged morphogenesis (ZDAREK *et al.*, 1976) microwaves have been found to cause specific tissues of an organism (DARDALHON *et al.*, 1979) ; D' AMBROSIO *et al.*, 1980; GREEN *et al.*, 1979). Some hypotheses are also existing concerning damage to gonial cells specially during larval-pupal pupal-imaginal transformation (RAI *et al.*, 1974). Exposure of biological systems to microwave/radio frequency energy leads to temperature increase when the rate of energy absorption exceeds the rate of energy dissipation. GORODETSKAYA *et al.* (1963) and ELY *et al.* (1964) have reported that testes and ovaries can be affected by high power density exposure of microwaves. These responses can be related to heating effects of microwaves as the sensitivity of testis to heat is well known (VAN DEMARK, 1973). In the present study the reduction in the cell and nuclear size in gonial cells, pycnosis of nuclei and loss of sperm motility may be a combined effect of thermal and nonthrrmal, probably biochemical effects of microwaves, which are to be identified.

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Entomon 1991 Vol. 16 No. 4 pp. 261 to 267

SOME OBSERVATIONS ON THE BIOLOGY AND BEHAVIOUR OF CRAZY ANT, *ANOPLOLEPIS LONGIPES* (JERDON) (HYMENOPTERA: FORMICIDAE)[1]

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(*Received* 30 *July* 1989)

An account is given on the biology of crazy ant, *Anoplolepis longipes* (Jerdon). A queen laid 7 to 22 eggs per day and the total number of eggs laid varied from 1960 to 2249 in 116 to 145 days under laboratory conditions. The mean duration of egg, larva and pupa was 18.6, 19.4 and 21.6 days respectively. The total life cycle was 59.6 days in case of worker ants. The longevity of worker, male and queen was 84.3, 10.5 and 137.5 days respectively. Worker population was made up of more than 98% of the total mean biomass weighing 21g. The biomass was low during the sexual brood production. The only period when alate males and females were produced was two months after the first showers or at the beginning of the wet season (April to May). The worker caste was produced throughout the year and reached a peak during and after wet season while the female reproductives were produced only during March-June.

(*Key words :* crazy ant, *A. longipes*, biology, sexual brood, biomass)

INTRODUCTION

The crazy ant, *Anoplolepis longipes* (Jerdon) is spread by commerce to many tropical countries including Sri Lanka, India and Burma (BINGHAM, 1903). VEERESH & GUBBAIAH (1984) reported that it has attained pest status in Mandhya district of Karnataka. An attempt has been made in the present investigation to study the biology and behaviour of crazy ant which forms basic information for evolving suitable management practices.

MATERIALS AND METHODS

Laboratory rearing of *A. longipes* was initiated with adult queens collected from the field in the month of August. To study the biology, five sets, each containing a queen and five workers were maintained separately in the laboratory in the test tubes of size 15 cm long and 2.5 cm diameter. Observations were made daily on the number of eggs laid by each queen till its death. Number of eggs laid on each day were counted and discarded. Ten eggs along with 5 workers were reared in similar test tubes for observing developmental stages and their duration.

Contents of nest: The contents of five nests of *A. longipes* were collected separately from the field, one each at three monthly intervals from July 1985 to July 1986 and the contetnts were sorted into nine stages; alate queens, dealate queens, alate males, workers, queen pupae, queen larvae, other larvae, other pupae and egg masses. Counts were made directly for the number of alate queens, dealate queens, alate males, queen pupae and queen larvae; counts for other stages were made by weighing the total

[1] Part of Ph.D. Thesis sumbitted by the first author.

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mass of each stage and converting into number by dividing unit weight of each stage. Mean biomass and the percent biomass of each stage to the percent of total biomass was also calculated.

Seasonal production of sexual brood and seasonal changes in colony biomass: During January, 1985 one hundred bamboo traps were spread randomly all over the study site. Each bamboo trap (6 to 8 cm diameter and 12 to 18 cm length) was stuffed with small quantity of leaf litter and moist soil and was burried in loose soil in a slanting position. All the temporary heaps with leaf litter or small stones were removed to facilitate an easy colonization.

From March 1985, three bamboo traps with colonies were collected at random from the sampling areas at monthly interval and the contents were segregated. The total biomass of each nest was calculated and also a record was maintained for different sexual stages and worker brood.

Since the production of sexual forms is dependent on the rainfall, correlations were made with rainfall to each stage of the brood and whenever significant correlations were obtained, regression equations were worked. Correlations were also worked out between adult population and that of rainfall that was received two months preceding the population count.

OBSERVATIONS

Biology:

The alate sexual forms emerged from March to May depending on the receipt of premonsoon showers. On an average, a female laid 16 eggs with maximum and minimum of 22 and 10 respectively per day. Average number of eggs laid per day in each of the five sets varied from 15.51 ($\pm$4.188) to 16.86 ($\pm$4.062). Total number of eggs liaid by a queen was 1960 to 2249 in 116 to 145 days. Data on duration and measurement of various stages are presented in Table 1.

Egg:

Eggs were laid singly. The worker ants with their saliva made them adhere to each other to form an egg mass containing 23 to 118 eggs (66.7$\pm$36.16). Incubation period varied from 16 to 25 days (18.6$\pm$1.70).

Larva:

The newly hatched larva was elongate to oval tapering at the anterior end with a small pointed and distinct head and broadly rounded at the posterior end. The body segments were indistinct but, with shallow grooves. At this stage the colour of the larva was glossy white and entirely naked. Some newly hatched larvae were also held together with the egg mass. On an average 7.92 ($\pm$0.92) newly hatched larvae were found adhering to egg mass. When the larvae measured 0.90 mm in length, the head and thorax had large number of hairs; with naked abdomen. After 8 days of hatching, the larvae separated out. Numerous fine long hairs were found on the abdomen of grown up larvae and the fully grown larvae became greyish and opaque. The total larval period occupied 19.4 days.

Pupa:

The larvae ready for pupation were carried by the workers to a separate place in the nest and provided with fine parcticles of soil, pieces of empty cocoons, fine threads including fallen human hair to serve as points of attachment for spinning cocoon. As soon as pupation was completed the workers removed the adhereing particles on the outer surface of the cocoon. Inside the cocoon, the larva became straight and

TABLE 1. Duration and measurments of various stages of *A. longipes*.*

Stage	Duaration (days) $\bar{x} \pm SE$	Measurements (mm) $\bar{x} \pm SE$	
		Length	Width
Egg	18.6 ± 1.70	0.30 ± 0.01	0.20 ± 0.03
Larval stage:			
(i) Early		0.52 ± 0.01	0.20 ± 0.23
(ii) Middle		0.90 ± 0.04	0.24 ± 0.12
(iii) Late	19.4 ± 1.09	1.93 ± 0.03	0.62 ± 0.03
(iv) Prepupa		2.96 ± 1.16	0.78 ± 0.01
Pupal stage	21.6 ± 1.13	3.55 ± 1.12	1.50 ± 0.11
Total life cycle of worker ant from egg to adult	59.6 ± 1.31	—	—
Worker	84.3 ± 5.98	4.25 ± 1.03	1.05 ± 0.11
Male	10.5 ± 1.27	4.25 ± 1.16	1.00 ± 0.11
Queen	137.5 ± 19.72	8.95 ± 0.13	2.55 ± 0.33

$\bar{x}$: Mean of the sample
SE : Standard deviation of $\bar{x}$
* : Mean maximum temperature : 26.2°C
Mean minimum temperature : 17.5°C
Range of relative humidity : 52–87%.

TABLE 2. Mean content and percentage occupancy of *A. longipes* with unit weight of different stages and biomass.*

Stage	Number in nest $\bar{x} \pm SE$	% of total number	Unit weight(mg) of stages $\bar{x} \pm SE$	Mean biomass (g)	% of total biomass
Egg masses	82.8 ± 24.6	0.563	3.222 ± 0.250	0.267	1.26
Larvae	2521.0 ± 1093.4	17.127	0.221 ± 0.020	0.557	2.63
Pupae	3727.0 ± 1411.9	25.320	1.818 ± 0.164	6.776	31.95
Queen larvae	3.4 ± 2.7	0.023	15.449 ± 0.870	0.053	0.25
Queen pupae	9.6 ± 9.5	0.065	18.015 ± 0.419	0.173	0.82
Alate queens	10.8 ± 9.2	0.073	22.453 ± 0.847	0.242	1.14
Dealate queens	24.2 ± 15.4	0.164	20.506 ± 0.500	0.496	2.34
Males	72.4 ± 80.6	0.492	1.026 ± 0.120	0.074	0.35
Workers	822.68 ± 3072.6	56.172	1.520 ± 0.127	12.568	59.27
Total	14,719.4			21.206	

*Mean of 5 nests collected from the field between July 1985 and July 1986.

rigid. The colour of the pupa was initially white and later changed to dirty white. Duration of the pupa destined to be a queen was 32.3 days. Adult workers frequently licked and aided the emergence of adults in peeling off the pupal skin.

Adults:

The three castes *viz.*, workers, male and female could be easily identified by the presence or absence of wings or by its size. The male did not shed the wings. Although the female shed its wings, it could be easily identified by its size. The body colour of worker adult was brownish red and the abdomen of the queen was black. The queen was almost 2.11 times bigger than the worker. The average weight of the dealate queen was 20.51 mg., of a worker 1.52 mg and a male 1.03 mg.

Contents of the nest:

An average colony consisted of 8 to 52 dealate queens, 14 to 28 alate queens, 0 to 173 alate males and 4580 to 13,125 workers, 82.8 egg masses (egg mass contained 23-118 eggs) and 2521 larvae. Alate queens and alate males were observed only during July, 1985 and April, 1986. Out of 21.21 g of biomass in the nest, workers constituted 56.17% of the individuals in the nest (Table 2).

Seasonal changes in colony biomass:

Total biomass of the colony varied considerably during the study period. Before the production of sexual brood, the total biomass was 27.53 g and 48.50 g in 1985 and 1986 respectively. The worker population comprised of 62.75 and 76.58% of the total biomass during these years respectively.

The biomass was low during the sexual brood production. Tne worker component of the total biomass declined to 53.47% and 48.89% in 1985 and 1986 respectively during sexual production.

Data on live weight as percentage of total biomass for different stages of *A. longipes* during the entire period of study is shown in Tabke 3. Relationship between rainfall (X) and number of adults per pupa of workers was worked out (Table 4).

Seasonal production of sexual brood:

There was only one period during the year when the production of sexual brood took place. In all the sites most of the sexual adults and brood were produced after the first showers. Dealate queens occurred throughout the year, but males (alate), alate queens, queen larvae and queen pupae could be seen during July to August and March to April (Table 3).

The time of the onset of sexual brood production corresponded closely with the first showers in both the years following the mid year dry season. In the year 1985, more than 30 mm rainfall was received in the month of March induced the queen to lay eggs which developed into sexual forms and they subsequently emerged in May. During 1986, rains were received in January and February at the study sites. This induced laying of eggs of sexual forms and they emerged in April itself. Alate males and females were observed from May to August (1985) and April to July (1986) in the study sites. Queen larvae and pupae were observed in the field a month and a half after receiving first rains in both the years (Table 3). Egg production was found throughout the year with peaks in July-October (1985) and March to July (1986). Adult worker and larval population was at peak during September and extended upto December.

TABLE 3. Biomass of *A. longipes colony during different seasons.*

Month	Live weight as a percentage of total biomass									Total biomass (g)
	Alate queens	Dealate queens	Males	Workers	Reproductives		Pupae	Larvae	Egg masses	
					Pupae	Larvae				
March 1985	0	2.10	0	71.50	1.12	1.10	19.90	0.35	3.98	32.24
April	0	3.72	0	62.75	3.73	2.81	18.55	0.36	8.07	27.53
May	1.44	2.78	1.17	65.65	3.27	2.98	17.93	0.25	4.52	34.68
June	2.80	2.87	1.09	62.05	2.25	3.92	17.68	0.51	6.83	26.42
July	5.14	4.41	0.80	53.47	1.66	0	18.50	1.06	14.96	29.28
August	3.68	3.37	0.26	62.83	0	0	17.10	1.57	11.19	38.39
September	0	1.37	0	76.09	0	0	16.74	0.97	4.83	70.45
October	0	1.77	0	77.68	0	0	15.08	0.24	5.22	72.79
November	0	1.10	0	76.87	0	0	19.57	0.15	2.31	74.48
December	0	1.34	0	79.61	0	0	16.49	0.15	2.43	73.19
January 1986	0	1.12	0	76.34	0	0	20.23	0.14	2.17	60.40
February	0	1.14	0	76.78	0	0.47	18.38	0.30	2.99	48.50
March	0.88	0.61	0	72.45	1.78	1.39	16.28	0.59	6.02	33.36
April	5.98	2.52	1.14	65.39	3.42	2.06	13.01	0.56	5.93	30.05
May	7.14	3.97	1.65	52.61	4.61	3.95	15.95	1.19	8.92	27.35
June	4.73	6.51	1.02	48.89	3.79	2.45	18.89	1.60	12.16	25.18
July	0	3.73	0.28	60.54	2.90	0	15.95	2.32	14.27	32.96

*Average of three bamboo traps in each month.

DISCUSSION

Observations of the present study on life cycle of a worker ant were found almost similar to the pattern reported from Java (VAN DER GOOT, 1916). According to FLUKER & BEARDSLEY (1970), *A. longipes* took 76 to 84 days in Hawaii.

The longevity of worker ant (84.3 $\pm$ 5.98), male (10.5 $\pm$ 1.27) and queen 137.5 $\pm$ 19.72) was far less as compared to the longevity recorded by DAMMERMAN (1929). According to him worker lived upto six months and that of queen probably for several years, and as regards the egg laying capacity of the queen it was 700 eggs annually but, in the present investigations queen lived for 137.5 days and laid on an average 2072 eggs under controlled conditions.

The castes were differentiated into workers, males (alate) and female (alate and dealate). The workers immediately after emergence were pale brown in colour and seldom found outside the proximity of the nests. The grown up workers attended the brood. FLUKER & BEARDSLY (1970) also made similar observations.

TABLE 4. Relationship between rainfall, brood and biomass.

Brood	With rain fall correlation "r" value		Regression equation
Alate queens	— 0.24	NS	—
Dealate queens	+ 0.09	NS	—
Males	— 0.37	NS	—
Workers	+ 0.74	**	Y = 9.78 −0.027 X
Queen pupae	— 0.58	*	Y = −70.04 −8.98 X
Queen larvae	— 0.67	**	Y = −69.70 −10.23 X
Pupae	+ 0.72	**	Y = 21.22 −0.16 X
Larvae	+ 0.18	NS	—
Egg masses	+ 0.23	NS	—
Total biomass	+ 0.77	**	Y = 27.94 + 1.69 X

* Significant at 5% only.
** Significant at 5% and 1%.
NS Not significant.
Tabulated 'r' value 5% = 0.482.
1% = 0.606.

In all the study sites, most of the sexual adults and their brood were found after the first rains after a prolonged dry period. Dealate queens occurred throughout the onset of sexual brood production corresponded closely with the rainfall in both the years of observation. In fact, the first showers induced the queens to lay eggs which developed into sexual forms. Alate queens and alate males occurred only during a limited period in a year, mainly before the wet season. In Indonesia also, winged sexuals appeared only after a prolonged drought (VAN DER GOOT, 1916). But in Seychelles (HAINES & HAINES, 1978a), Solomon Islands (GREENSLANDE, 1971b) and Papua New Guinea (BAKER, 1976) alates occurred throughout the year, although peak production of males was generally at the end of dry season. But in the present studies alates occurred only once in a year *i. e.*, in the beginning of the rainy season, some time during March to May. At no time, the alates were found flying although they were found near the light source at times reached by crawling. Workers were produced throughout the year as was reported by HAINES & HAINES (1978).

Total biomass of a colony varied considerably during the study period. The biomass of a nest was the least during the sexual brood production apparently due to less number of worker brood. Worker population reached its peak in winter and also in wet months during which period the sexual brood production was almost nil and the total biomass was highest. The biomass of a nest was more during wet months and less in dry months. However, BAKER (1976) observed that the

biomass of colony was more in Papua New Guinea during the sexual brood production.

In the present studies adult workers and their immature stages constituted more than 98% of the total population. HAINES & HAINES (1978) reported the same upto 95% from Seychelles.

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INFLUENCE OF POPULATION DENSITY OF SILKWORM, *BOMBYX MORI* L. ON SOME ECONOMIC TRAITS

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A uni-bi-voltine hybrid ('J 122' × 'Halauk') of silkworm was reared during spring, summer and autumn seasons of Kashmir valley in five different population groups of 100, 200, 300, 400 and 500 worms with a uniform bed space of 6 sq. ft.

Population group of 300 worms exhibited good results in spring whereas the population group of 200 worms behaved invariably well in summer and autumn. A bed space of 1000 sq. ft. is recommended as the optimal bed area for rearing 100 dfl's (50,000 – 60,000 worms) at cellular level in Kashmir.

(*Key words*: silkworm, *Bombyx mori*, population density effects, economic traits)

INTRODUCTION

In nature the species are influenced by food and spacing for their existence, and the progenies and population of a species remian healthy and fixed under the optimum conditions of nutrition and space (NICHOLSON, 1958).

In silkworm, *Bombyx mori* L., the larval behaviour, yield of cocoons and cocoon features are determined by the space given to the worms during rearing especially in the 5th instar. The requirement of space for the worm is maximum a day or two before ripening. At this stage the worm increases by about ten thousand times in weight, seven thousand times in volume and four hundred times in body surface to become a full grown mature larva (YOKOYAMA, 1962). Under these circumstances it becomes essential to provide adequate spacing to the worms in rearing beds so as to enable the larvae to eat enough actively in accordance with their growing stage so that a successful harvest of bumper cocoon crop is ensured. Crowded populations on the other hand, besides leading to competition for food, greatly affect the physiology and general health of worms.

Many attempts have been made in the past (YOKOYAMA, 1962; TANAKA, 1964; SENGUPTA & YUSUF, 1974; KRISHNASWAMI, 1971, 1978; KRISHNASWAMI et el., 1973; ANONYMOUS, 1972, 1975) to find out the optimum spacing of the worms in rearing beds in different sericulture zones of the world. But none of these studies refer to the optimum spacing which could be implied for rearing of silkworms in the Kashmir valley, a temperate zone. This prompted to determine the impact of spacing on larval behaviour in 4th and 5th instars and cocoon features of uni-bi-voltine silkworms reared in temperate zone and are reported here.

MATERIALS AND METHODS

Rearing of 'J 122' × 'Halauk' hybrid was performed across the three possible rearing seasons, viz., spring (April – May), summer (June – July) and autumn (August–September) of Kashmir valley in 1985.

Normal rearing was conducted upto 3rd moult as per routine (ANONYMOUS, 1988). In 4th and 5th instar, the worms were separated into five uniform spacing of 6 sq. ft. for each group, replicated four times. The groups included 100 (group I), 200 (group II), 300 (group III), 400 (group IV) and 500 worms (group V).

Mulberry leaf was fed four times a day. The rearing beds were cleaned once a day. Four locally made grass cocoonages were used for mounting of the ripe worms of a replication in each group.

Data on mortality, weight of ten mature larvae (g), yield of cocoons per 10,000 larvae by number and weight (kg), deformed cocoon percentage, single cocoon weight (g), shell weight (cg) and shell percentage were recorded and analysed statistically. For calculating single cocoon weight, shell weight and shell percentage random sample of 20 cocoons (10 male and 10 female) were used to get the average for each replication.

RESULTS AND DISCUSSION

The weight of 10 mature larvae was significantly higher in the population group II than the other groups except for group I and in spring rearing, whereas in summer and autumn there was no statistical difference. However, in summer group III and in autumn group II gave the higher weights (Table 1).

Population group I in all the seasons encountered a low rate of larval mortality significantly not different from the group II and III in spring, groups II and IV in summer and group II in autumn.

The yield of cocoons per 10,000 larvae by number was significantly more in group III in spring. In summer and autumn groups II and I respectively gave higher yields than the other groups.

There was no statistical difference amongst various population groups for the yield of cocoons per 10,000 larvae by weight in spring and autumn. However, the population group III gave higher yields in both the seasons. In summer the yield in III and II was / significantly higher than the other groups.

The percentage of deformed cocoons was significantly less in group I in all seasons but significantly not different from the groups III, II and groups II and III in spring, summer and autumn, respectively.

The weight of single cocoon was significantly more in group III in spring than other groups except for group II. Similarly, in summer group II gave significantly heavier cocoons, not different from group III and IV, while in autumn though no significant difference were observed the weight was higher in group II.

No statistical difference for shell weight was observed in the three seasons, however, in spring it was higher in group III and in summer and autumn group II gave the higher values.

The shell percentage was higher in group-III and II in spring and autumn respectively, but the differences from the other groups being statistically not significant. However, in summer group II gave significantly higher shell percentage than the other groups except for group III.

In order to see the interaction of population groups with different seasons, the data for all these characters was further put to analysis of variance (Table 2). The variances due to the groups were significant in all the characters except for shell percentage. Variances due to seasons was significant in all the characters. However, the interaction of groups × seasons was

TABLE 1. Larval and cocoon features under different population group of *Bombyx mori* L.

Parameter	Season	Population group					C. D.	
		I	II	III	IV	V	5%	1%
Weight of ten mature larvae (g)	Spring	52.40	53.03	50.25	47.73	46.85	2.68	3.76
	Summer	35.43	37.70	38.13	37.48	33.15	N.S.	N.S.
	Autumn	32.13	35.58	33.80	33.88	34.80	N.S.	N.S.
Larval mortality (%)	Spring	1.85 (7.73)	4.45 (12.12)	3.45 (10.75)	11.15 (19.40)	16.15 (20.71)	4.95	6.94
	Summer	4.35 (11.98)	6.45 (14.69)	8.35 (16.79)	7.65 (16.10)	18.75 (25.66)	3.77	5.28
	Autumn	1.45 (6.94)	1.85 (7.85)	3.95 (9.86)	3.75 (11.14)	6.05 (14.29)	1.98	2.77
Yield/10,000 larvae by weight (kg)	Spring	12.625	12.650	14.775	12.850	13.300	N.S.	N.S.
	Summer	13.080	14.288	14.875	13.219	9.750	1.632	2.228
	Autumn	14.100	14.725	15.067	13.888	13.835	N.S.	N.S.
Yield/10,000 larvae by no.	Spring	6400	6357	9425	8350	7320	410	575
	Summer	8000	8637	8283	7525	6494	838	1175
	Autumn	8875	8795	8691	7957	8085	436	611
Deformed cocoons (%)	Spring	0.05 (1.30)	1.75 (7.80)	0.25 (3.02)	0.85 (5.35)	3.35 (10.59)	3.57	5.01
	Summer	1.15 (6.10)	2.45 (8.95)	4.85 (12.76)	7.55 (15.91)	7.65 (16.06)	4.40	6.17
	Autumn	0.05 (1.50)	1.45 (6.88)	3.85 (11.37)	1.95 (8.07)	2.95 (9.84)	3.70	5.19
Single cocoon wt. (g)	Spring	2.20	2.28	2.32	2.19	2.22	0.06	0.08
	Summer	1.55	1.62	1.58	1.58	1.53	0.05	0.07
	Autumn	1.50	1.55	1.54	1.47	1.48	N.S.	N.S.
Single shell weight (cg)	Spring	46.75	46.75	50.00	46.00	44.75	N.S.	N.S.
	Summer	26.25	31.25	30.50	29.25	26.75	N.S.	N.S.
	Autumn	29.00	31.25	29.75	27.00	29.75	N.S.	N.S.
Shell percentage	Spring	21.25 (27.45)	20.35 (26.84)	21.60 (27.69)	20.95 (27.26)	20.05 (26.61)	N.S.	N.S.
	Summer	17.85 (24.28)	19.34 (26.09)	19.25 (26.02)	19.25 (26.02)	18.45 (24.73)	1.40	1.96
	Autumn	19.40 (26.13)	20.25 (26.74)	19.45 (26.15)	18.34 (25.37)	20.05 (26.61)	N.S.	N.S.

The figures in parentheses are angular values.

TABLE 2. Mean squares of some economic characteristics in *Bombyx mori* L.

Source of variation	df	Weight of ten mature larvae (g)	Larval mortality (%)	Yield per 10,000 larvae by number	Yield per 10,000 larvae by weight (kg)	Deformed cocoons (%)	Single cocoons weight (g)	Single shell weight (cg)	Shell percentage
Replications	3	12.1473	1.9753	1603333.33	0.2689	2.9660	0.0029	2.6222	1.2800
Treatments	14	230.3417	108.4359	3701428.57	7.1342	22.5826	0.4825	335.25000	7.0372
Seasons	2	1503.9045	186.3332	4825000.00	9.5151	67.0012	3.3333	2107.8500	32.7977
Groups	4	24.0547	226.1200	3590000.00	10.9782	33.0897	0.0172	25.4166	2.4389
Seasons × Groups	8	15.0945	30.1196	3476250.00	4.6171	6.2245	0.0025	9.5166	2.8962
Error	42	5.5116	4.3579	484525.809	2.4404	1.7012	0.0042	8.4912	1.3593
C.D. 1%		4.488	3.991	1330.9144	2.9869	2.4938	0.1239	5.571	2.229
C.D. 5%		3.354	2.983	994.740	2.232	1.8639	0.0926	4.1642	1.666

significant only for weight of ten mature larvae, percentage larval mortality, yield of cocoons per 10,000 larvae by number and percentage of deformed cocoons.

From the foregoing account, it is clear that the silkworms reared in the groups of 100, 200 and 300 worms, in a uniform bed area of 6 sq. ft. invariably gave better results (Table 1) than the other groups. Interestingly, in spring season the population group of 300 worms exhibited good results, whereas in summer and autumn seasons the population group of 200 worms/ 6 sq. ft. precisely behaved well compared to population group of 100 worms/6 sq. ft. of spacing. Taking on average of 500 worms per one disease free laying (dfl) in 5th instar the space requirement of 1,000 sq. ft. in spring season seems to be optimum for rearing 100 dfls (50,000 worms).

YOKOYAMA (1962) has given an area of 190 tsubo (1 tsubo = 3.95 sq.yd.) per 10 g of silkworm eggs of bivoltine races as an optimal space in 5th instar for cellular rearing under Japanese conditions. However, TANAKA (1964) recommended 90 syaku sq. (1 syaku sq.=0.355 sq. ft.) for rearing 3.75 g of newly hatched larvae. Further, a spacing of 371.36 sq. ft. (ANONYMOUS, 1972) and 203.44 sq. ft. (ANONYMOUS, 1975) for rearing 20,000 grown larvae in 5th instar under Japan climate has also been advocated. Similarly, in tropical regions such as Karnataka, India, KRISHNASWAMI (1971) suggested an approximate area of 230 sq. ft. for rearing 100 dfls (approximately 40,000 worms) of eggs of multivoltine races/crosses, whereas SENGUPTA & YUSUF (1974) observed a spacing of 500 sq. ft. for cellular and 300–350 sq.ft. for mass rearing of the same number of worms of multivoltine races to be optimal in the tropical rearing conditions of West Bengal. Recently, KRISHNASWAMI (1978) suggested an area of 360 sq. ft. to be optimal spacing for

rearing 100 dfls at cellular level in Karnataka and an area of 215.3 sq.ft. was considered to be optimal spacing for mass rearing of 100 dfls of silkworms in the same region (KRISHNASWAMI et al., 1973).

In the light of these findings on the optimal space requirements, the present study undertaken in Kashmir conditions having revealed 1000 sq.ft. as the optimum space for cellular rearing of 100 dfls (50,000 worms) in the 5th instar, is suggestive of the fact that the different spacings would be required for conducting rearing in different zones depending on the method of rearing, the rearing conditions such as environmental temperature and humidity and also the grown stage of the larvae. Furthermore, average dimension of the full grown larvae of the test material being 2.8" × 0.5" the spacing of 1000 sq. ft. per 50,000 worms corroborates with the spacing formula of MASUI, 1929 (quoted by TANAKA, 1964). The area can be smaller in case of lower temperature and higher humidity than higher temperature and lower humidity and in the spare-or moderate-eating stage than active-eating stage (YOKOYAMA, 1962). Since spring in Kashmir is the most conducive season for silkworm rearing, a spacing of 1,000 sq. ft. per 100 dfls for cellular rearing provides practically no adverse impact on the development and survival of the worms. On the other hand, summer and autumn seasons in the valley are notably different and less favourable for rearing than the spring, the rearing can be managed by frequent cleaning of the rearing bed and by removal of unconsumed leaf.

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Entomon 1991 Vol. 16 No. 4 pp. 275 to 277

BREEDING OF *BLEPYRUS INSULARIS* (HYM., ENCYRTIDAE) ON *FERRISIA VIRGATA* (HEMIP., PSEUDOCOCCIDAE)

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The striped mealybug *Ferrisia virgata* (Ckll.), was multiplied on pumpkin fruits in the laboratory, the different stages of which were used to rear the encyrtid parasitoid *Blepyrus insularis* (Cam.). The parasitoid was able to complete the development in nymphal stages of the mealybug in about 32 days at 26 ± 1.8°C and 60-70% RH. The age of the mealybug did not affect the duration of parasitoid development, but had significant influence on progeny production. The first two nymphal stages (5-10 days) of *F. virgata*, when got parasitised, yielded significantly more number of parasitoid progenies, and were recommended for the breeding of *B. insularis*.

(*Key words: Ferrisia virgata*, *Blepyrus insularis*, Encyrtidae, Pseudococcidae, mealybug, parasitoid, breeding)

INTRODUCTION

The striped mealybug, *Ferrisia virgata* (Ckll.) is a severe pest of guava and custard apple (MANI & KRISHNAMOORTHY, 1988, 1989) in Southern India. As many as 58 species are known to parasitise *F. virgata* in nature (MANI & KRISHNAMOORTHY, 1991). *Blepyrus insularis* (Cam.) is a solitary, uniparental and internal encyrtid parasitoid of *F. virgata*. It was causing upto 32% parasitism in *F. virgata* infesting guava plants (MANI & KRISHNAMOORTHY, 1988). Not much information, except the report of TIMBERLAKE (1922) on the identity and habits of *B. insularis*, especially on its rearing technique is available. Considering its importance, an attempt was made to develop a breeding technique for *B. insularis* utilising the different stages of the mealybug, *F. virgata*.

MATERIALS AND METHODS

F. virgata was maintained on ripe pumpkins (*Cucurbita moschata* Duchesne) in the laboratory as outlined by CHACKO *et al.* (1978) for *Planococcus citri* (Risso). Being viviparous, gravid female mealybugs were kept over the pumpkins for 24 h. Pumpkins infested with crawlers on different dates were arranged in racks for further development.

Adults of *B. insularis* were obtained from the cages in which field collected mealybug infested guava fruits and shoots were kept. Newly emerged adults were collected and fed with 50% honey solution. Adult parasitoids of 1–2 days old were used for exposure to different stages of the mealybug.

Pumpkin fruits each colonised with about 500 mealybugs, were used to determine the host stage suitability for the breeding of *B. insularis*. Mealybug infested pumpkins, held in wooden cages (30 × 30 × 30 cm), contained either 1st instar (1 day old), 1st instar (5 days old), 2nd instar (10 days old), 3rd instar (15 day old) or adult female mealybugs (20 day old). Each stage was exposed seperately to 40

Contribution No. 79/90 of I.I.H.R.

adults of *B. insularis* for 24 h. Five replicates were maintained for each stage. Parasitoid emergence was recorded daily. Based on adult emergence, the developmental period of the parasitoid on each stage of the mealybug was worked out.

The data on the number of parasitoids emerged were transformed into $\sqrt{x+0.5}$ and used for statistical analysis by applying 'F' test. All the studies were conducted at 26°C±1.8°C and 60–70% R.H. in the laboratory.

RESULTS AND DISCUSSION

All the mealybug stages except adult females were susceptible to parasitism by *B. insularis*. The parasitoid developed and emerged successfully only in the nymphal stages of *F. virgata* as also reported earlier by (TIMBERLAKE, 1922).

Analysis of variance indicated that the stage of the mealybug parasitised had significant influence on the progeny production, but not on the parasitoid's developmental time. A significant higher number of 147.48 offsprings emerged from the parasitised second instar nymphs. Even within first instar itself, five-day-old nymphs, when parasitised, yielded significantly more offsprings than one-day-nymphs. Number of parasitoids emerged from third instar nymphs was significantly low (17.75), while that from adult female nil. According to TIMBERLAKE (1922), this parasitoid was comparable with yet another encyrtid, *Coccidoxenoides* (Pauridia) *peregrina* Timberlake which had emerged in large numbers from 8-day-old parasitised mealybugs (ANONYMOUS, 1988).

Developmental times for *B. insularis* are presented in Table 1. The age of the mealybug did not affect the duration of the parasitoid development. Similar result with other encyrtids like *Anagyrus pseudococci* (Gir.) on *P. citri* (CHANDLER *et al.*, 1980) and *A. dactylopii* (How.) on *Maconellicoccus hirsutus* (Green) (MANI & THONTADARYA, 1989) had also been reported earlier. The mean total developmental time (egg to

TABLE 1. Adult emergence and developmental time in relation to the age of *Ferrisia virgata*.

Mealybug stage	No. of adults emerged		Developmental time (days)	
	Mean	S.D.	Mean	S.D.
I instar (1 day old)	60.00 (7.78)	7.82	31.03	4.20
I instar (5 days old)	104.50 (9.98)	15.24	32.15	2.94
II instar (10 days old)	147.48 (12.27)	9.55	32.04	1.86
III instar (15 days old)	17.75 (5.37)	4.36	31.18	1.53
Adult females (20 days old)	—	—	—	—

Level of significance		C.D. ($p=0.05$)
Adult emergence	0.01	0.36
Developmental time	N.S.	—

adult) of *B. insularis* varied irom 31.18 to 32.15 days on different stages of *F. virgata* parasitised. Our result closely resembles with TIKBERLAKE (1922) who had reported *B. insularis* completing life cycle in 32 to 45 days.

Mealybugs of 5–10 days old, which yielded more number of parasitoids, were chosen for exposure to *B. insularis*, and the parasitoid was bred in the laboratory continuously for more than one year.

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Entomon 1991 Vol. 16 No. 4 pp. 279 to 282

MODE OF HUNTING AND FUNCTIONAL RESPONSE OF THE SPIDER *MARPISSA TIGRINA* TIKADER (SALTICIDAE : ARACHNIDA) TO THE DENSITY OF ITS PREY, *DIAPHORINA CITRI*

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The mode of hunting in *Marpissa tigrina* Tikader is typical of a carnivore predator. Both the sense of sight and touch are involved in the perception of the prey. After locating the prey, the spider creaps cautiously towards the prey so as not to disturb it, finding the prey in its jumping range, pounces upon it. The spider is capable of capturing 3-4 citrus psylla, *Diphorina citri* one after another and feeds on them all at a time.

***M. tigrina* shows a functional response to increasing density of its prey (citrus psylla) which is a serious pest of citrus. The number of prey consumed daily by an individual spider increased with the increase in prey density up to 40. With the further increase in prey density, the rate of predation decreased progressively at a reduced rate. The results reveal that the spider is a highly beneficial predator of citrus psylla.**

(*Key words: Marpissa tigrina*, hunting, functional response, *Diaphorina citri*)

INTRODUCTION

Spiders are well known for their predatory activity on insect pests and other arthropods. However, there is little information on predator-prey relationships which represents an important component of field population ecology. There is also a great interest in the problem of how predator population affects the population of their prey. For assessing the performance of a predator, the first step is to learn as to how it performs as an individual particularly the way it searches its prey, perceives the prey and accepts or refuses given prey individuals (HUFFAKER *et al.*, 1971). The knowledge of functional response of individual is, therefore, essential for a clear understanding and approach to modelling predator-prey interactions. The functional responses of predators were studied in detail by HOLLING (1959 a, b, 1961, 1966).

During the course of investigations of spider fauna of citrus orchards at the Punjab Agricultural University, it has been observed that *Marpissa tigrina* Tikader has great potential for preying on citrus psylla, *Diaphorina citri*, a serious pest of citrus. Hithertofore, this spider has also been reported to be a voracious feeder of fulgorid pest of grapevine i.e., *Amrasca biguttula biguttula* (SADANA & KAUR, 1980). It was, therefore, considered worthwhile to study the mode of hunting and to assess the functional response of this spider to the density of its prey, citrus psylla.

MATERIALS AND METHODS

The adult females of *M. tigrina* were reared individually in the laboratory cages. The latter consisted of a lantern chimney placed over a petridish paved with moist soil and then filter paper and covered by a

piece of muslin cloth tied with the help of a rubber band. The spiders were starved for 24 hours before the start of experiments and then provided with different number of nymphs of citrus psylla i.e., 10, 20, 30, 40, 50, 60 and 70 in ten replicates. A few leaves of citrus were also introduced in the laboratory cage which served as food for the prey. The number of nymphs consumed by each spider was recorded after 24 hours of starting the experiment. Observations were also recorded on the searching method used, mode of perception of prey and attack by *M. tigrina*.

RESULTS AND DISCUSSION

Perception of prey and hunting:

M. tigrina searches its prey with its keen eye sight besides depending upon contact stimulus. It creaps about, stops every now and then, raises its head and gazes around its neighbourhood. As it receives stimulation due to the movement of its prey, it starts approaching the prey with caution so that its own movements are imperceptible to the prey. Such smooth and creeping movements are often accompanied by fluttering of palpi. At times, when the prey approaches from behind and touches the body or legs of the spider, it turns quickly to face the prey. When the prey comes within the jumping range which is almost double the length of its body, it suddenly leaps upon the prey with an unerring aim. The jumping distance in salticids varies greatly (SNETSINGER, 1955; BRISTOWE, 1958). Just before jumping, the front legs are extended forward for seizing the prey. A similar attacking posture is reported in the Thomisid spider, *Philodromus-rufus* (HAYNES & SISOJEVIK, 1966).

TABLE 1. Influence of prey, *Diaphorina citri* density on the number of prey consumed by the predator, *Marpissa tigrina*.

Treatment Group	Number preyed upon						
	10	20	30	40	50	60	70
1	10	14	15	18	15	14	13
2	10	16	15	19	16	17	14
3	10	12	17	15	14	15	14
4	10	15	18	18	16	16	15
5	10	17	15	15	15	17	16
6	10	18	14	13	18	14	13
7	10	15	16	15	17	15	15
8	10	13	18	17	19	17	16
9	10	12	19	18	17	14	13
10	10	18	15	19	16	13	14
Mean	10.0	15.0	16.2	16.7	16.3	15.2	14.3
Average %	100	75	54	41.7	32.6	25.3	20.4

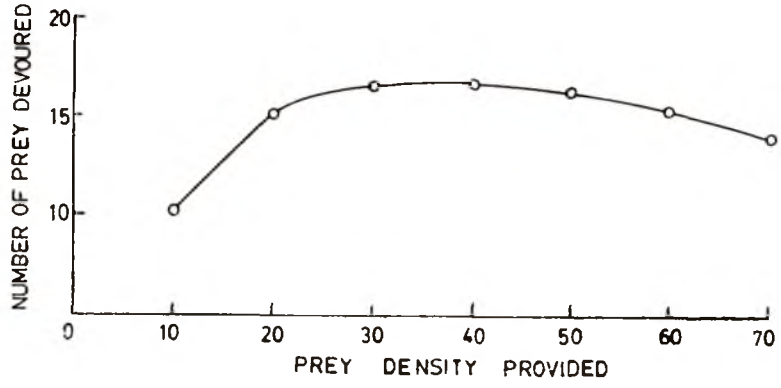

Fig. 1. Functional response of *Marpissa tigrina* in relation to prey, *Diaphorina citri* density.

Mode of feeding:

The manipulation of prey during feeding is done through palpi. The Prey is crushed with chelicerae to squeeze out body juices on which the spider feeds. It discards the hard parts of prey which are rolled into a ball like structure by the manipulation of palpi. Partial digestion of the prey before ingestion takes place in preoral cavity. The latter has endites on either side containing maxillary glands. HAYNES & SISOJOVIC (1966) also reported partial digestion before ingestion in *P. rufus*.

Functional response to prey density:

The results of the experiments on functional response of *M. tigrina* to the prey (citrus psylla) density are presented in Table 1 and Fig. 1. It is evident that the number of prey consumed daily increased with increase in prey density upto 40. With further increases in prey density, the predation decreased progressively at a reduced rate. This indicates declining functional response of *M. tigrina* at higher prey densities. The functional response curve of *M. tigrina* to prey density (Fig. 1) is closely similar to the curve described by HAYNES & SISOJEVIC (1966) for functional response of the spider *Philodromus rufus* Welck. (Fam. Thomisidae) to the density of *Drosophila*. An S-shaped or sigmoid curve is characteristic of the functional response of various predators (HOLLING, 1961; HUFFAKER *et al.*, 1971).

The declining trend in functional response of *M. tigrina* may be due to the disturbance caused by the prey to the predator because of overcrowding at the higher densities and also due to the limit on extent of feeding. Though the functional response of *M. tigrina* shows a declining trend after a certain rise to plateau, this does not mean that the predatory spider is unable to regulate population of its prey in a realistic population-interaction situation. In the field, there is not one predatory spider which is working at high densities of prey. *M. tigrina* is, therefore, a useful predatory spider which can be exploited to economic advantage for the control of citrus psylla.

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Entomon 1991 Vol. 16 No. 4 pp. 283 to 285

PREDATORY POTENTIAL OF THE LYSSOMANID SPIDER, *LYSSOMANES SIKKIMENSIS* TIKADER ON THE MANGO HOPPER, *IDIOSCOPUS CLYPEALIS* (LETHIERRY)

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The studies on the predatory potential of the lyssomanid spider, *Lyssomanes sikkimensis* Tikader on the mango hopper, *Idioscopus clypealis* (Lethierry) have revealed that the spider is highly beneficial predator. It has significantly more predatory potential compared to its developmental instars. Statistically, there is no signifiant difference between the predatory potential of second and third instar spiderlings and between fourth to sixth instar spiderlings. The predatory potential differed significantly between adults and developmental instars at 5% level of significance.

(*Key words:* predatory potential, *Lyssomanes sikkimensis*, *Idioscopus clypealis*)

INTRODUCTION

With the current concern surrounding indiscriminate use of insecticides to control insect pests of crops leading to unnecessary pollution of environment and disturbance in natural balance of predators, the use of biological control alone or along with chemical control takes on greater significance. This would help in judicious and correct use of insecticides and contamination of environment would be kept at tolerable levels and natural balance of predators would not be disturbed.

As biocontrol agents, spiders which constitute one of the dominant community of polyphagous predators, attract our attention. Although incidence of predation on insect pests by spiders have been reported by many workers their role in controlling insect populations is largely a matter of conjecture. In fact, very little efforts have been made to evaluate feeding potential of spiders on different kinds of insect pests. With this view in mind, the present work was undertaken to record the predatory potential of the lyssomanid spider *Lyssomanes sikkimensis* Tikader which occurs in great abundance in mango orchards and is predator of the mango hopper, *Idioscopus clypealis* (Lethierry).

MATERIALS AND METHODS

The spider, *L. sikkimensis* and the mango hopper, *I. clypealis* were collected from the mango trees grown at the Punjab Agricultural University, Ludhiana for conducting experiments to study the predatory potential of the spider. The spider was reared in the laboratory to know the number of instars in its life history. This also helped to know the exact instar being used in various experiments. Five individuals of each of the developmental instars as well as of the adult spider were starved for 24 hours before starting the experiments. Each specimen was housed in a large lantern chimney placed over a petridish paved with moist soil and then with filter paper and covered over with a piece of muslin cloth tied with a rubber band. Two leaves of mango with 10 nymphs of mango hopper were introduced in

TABLE 1. Predatory potential of different developmental instars of *Lyssomanes sikkimensis* on the mango hopper, *Idioscopus clypealis*.

Stage of spider	Number of mango hoppers eaten/24 hours					Total	Average
	R_1	R_2	R_3	R_4	R_5		
Second instar	0	0	0	0	0	0	—
Third instar	1	1	0	1	0	3	0.6
Fourth instar	2	2	3	2	3	12	2.4
Fifth instar	3	3	4	3	3	16	3.2
Sixth instar	5	5	5	6	5	26	5.2
Adult	10	10	9	10	9	48	9.6
Total	21	21	21	22	20	105	

Analysis of variance

Source	D.F	S.S	M.S.S.	Calculated F value
Stages of spider	5	310.3	62.06	253.3
Replications	4	0.3	0.075	0.306
Error	20	4.9	0.245	
C.D. at 5%	2.188			

each of these duly numbered chimneys and observations were recorded after 24 hours to see the number of insects consumed by each spider/developmental instar.

The data obtained were analysed statistically to determine the extent of predation and to know as to which instar is a potential predator.

RESULTS AND DISCUSSION

The results of the experiments on the study of predatory potential of *L. sikkimensis* on *I. clypealis* are depicted in Table 1. It is evident from the data that the predatory potential of different developmental instars on *I. clypealis* is not the same for all the instars. The predatory activity increased with the advancement of age of spiderlings. The adult spider has significantly more predatory potential compared to developmental instars. The analysis of the data shows that there is no significant statistical difference between the predatory potential of second and third instar and between fourth to sixth instar spiderlings. However, there is significant statistical difference in the predatory potential between adult spiders and developmental instars.

The adult spider is highly beneficial predator of *I. clypealis* although its developmental instars also take a heavy toll of this pest. The present results are closely similar to the findings of SADANA & SANDHU (1977), on *Marpissa ludhianaensis*, a potential predator of *Brahmaloka* sp. which infests grapevines. The findings of PATEL & PILLAI (1989) on *Clubiona pashabhaii*, a predator of cotton pests viz., aphid (*Aphis craccivora*) jassid

(*Amrasca biguttula biguttula*) and cotton bollworms (*Heliothis armigara* and *Earias vittella*) and PATEL *et al.* (1988) on different spider species predatory on jassid (*Amrasca biguttula biguttula*) are also similar to the present results.

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Entomon 1991 Vol. 16 No. 4 pp. 287 to 290

COLOUR PREFERENCE OF *DIALEURODES PALLIDA* SINGH, A KEY PEST OF *PIPER BETLE* L. IN TRIPURA[1]

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In multiple colour choice tests, out of 7 colours, maximum catches of adult *Dialeurodes pallida* Singh were obtained by using yellow sticky traps, followed by red. In paired colour choice tests, 7 colours used in different combinations, showed significantly different catches except between green - blue and blue - violet.

(*Key words:* colour preference, *dialeurodes pallida*, *piper betle*)

INTRODUCTION

Dialeurodes pallida Singh (Hemiptera: Aleyrodidae), recorded for the first time in Bihar as a pest of *Piper betle* L. (SINGH, 1931) is a monophagous species. Its distribution is reported to confine to India (MOUND & HALSEY, 1978). During the last few years this insect has attained the status of a serious pest in betelvine agroecosystem of Tripura. The larvae suck the leaf sap which affects adversely the vitality of the creeper, exude honeydew which attracts fungus and secrete wax which along with the cast exuviae produce spots on the leaves. As a result of the infestation, the market value of leaves, according to conservative estimates, is reduced by 20 to 30 per cent. The adult flies are small (about 1 mm), numerous, remain in clumps on lower surface of the apical leaves and move away at the slightest disturbance. All these charateristics make conventional sampling of population difficult.

The present paper evaluates, for the first time the efficacy of various colour traps for both control and early warning of *D. pallida* in betelvine conservatories.

MATERIALS AND METHODS

The sticky traps were prepared by using oil paint on both sides of cardboards and after the paint dried, a thin film of white grease was applied prior to the commencement of the experiment. The 24 cm^2 traps were placed in a vertical position on the top of the plants in the conservatory. For multiple choice of colour, seven colours *viz.*, yellow, red, green, violet, blue, white, black and transparent (no colour) as check were used in randomized-block design and were replicated thrice. Each replication consisted of six traps. Each colour was also compared with the rest colours in pairs to determine the colour preference.

RESULTS AND DISCUSSION

The multiple choice test (Table 1) revealed that the most abundent catches were made using yellow traps. The next most effective colour, which significantly differed from yellow, was red. The relative

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effectiveness of the other colour traps were found in the order: green > violet > blue > white > black. However, no clear-cut significant groups could be detected among them. In paired colour trap studied (Table 2) yellow, red, green, blue, violet, white and black were compared between each other. In all the cases except between green-blue and blue-violet, catches differed significantly.

TABLE 1. Multiple choice of colour by *Dialeurodes pallida*.

Colour	Mean catch/trap/day*
Yellow ..	39.0
Red ..	23.3
Green ..	13.3
Violet ..	9.1
Blue ..	8.4
White ..	4.5
Black ..	4.4
Transparent (check) ..	2.6
S Em± ..	4.52
CD at 5% ..	5.74
CD at 1% ..	7.94

* Based on three replications in R.B.D., each replication consisted of 6 traps.

A number of studies conducted on whiteflies (LLOYD, 1921; TREHAN, 1941; VISHAMPAYAN *et al.*, 1975 a, b; BERLINGER, 1980; EKBOM, 1982) confirm our present findings in which maximum number of catches were made using yellow traps. Yellow sticky traps should, however, be used with caution. At low densities the use of traps alone may not be feasible since it is not known as to what radius or distance of attraction a yellow trap has. Further, its attraction to predators and parasites needs to be investigated before the sound conclusion with regard to its scope arrived at.

The use of traps is recommended as a complement to weekly inspection of the plants in the conservatory. The most reliable estimates can be obtained by using yellow traps, placed on the top of the plants. The placing of traps at the top of the plants is important, for the whiteflies are not very active insects and often sit on the same leaf for a long time. It is only after emergence that they move to the tender apical leaves where the sticky traps will be effective in catch-the newly emerged whiteflies.

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TABLE 2. Choice of colour by *D. pallida* Singh (No. of traps used in each colour pair-6).

	Colour pair	Mean catch/ trap	Z	Colour pair	Mean catch/ trap	Z
I.	Yellow	33.4	4.0*	Yellow	42.2	22.59*
	Red	15.0		Green	12.6	
	Yellow	25.0	8.32*	Yellow	40.6	6.63*
	Blue	6.8		Violet	8.4	
	Yellow	45.4	24.14*	Yellow	36.2	10.38*
	White	5.4		Black	4.2	
II.	Red	25.4	2.58*	Red	16.2	4.42*
	Green	14.8		Blue	9.6	
	Red	28.4	4.82*	Red	13.4	4.53*
	Violet	13.2		White	5.2	
	Red	15.4	7.86*			
	Black	4.0				
III.	Green	13.6	1.58	Green	14.6	5.17*
	Blue	11.6		Violet	9.6	
	Green	10.6	3.69*	Green	16.4	2.43*
	White	5.2		Black	5.8	
IV.	Blue	12.2	1.68	Blue	8.6	6.07*
	Violet	9.2		White	4.6	
	Blue	3.0	1.52			
	Black	4.4				
V.	Violet	8.6	4.47*	Violet	7.0	3.23*
	White	4.6		Black	3.8	
VI.	White	4.2	2.6*			
	Black	2.4				

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CONSERVATION OF ECOSYSTEM WITH HIGHER PROFIT THROUGH INTEGRATED PEST MANAGEMENT IN COTTON

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Integrated pest management studies were undertaken at Agricultural Research Station, Dharwad, Karnataka State. Selective and effective insecticides like phosalone and cypermethrin, safe to the natural enemies in cotton eco-system along with release of egg parasites, *Trichogramma achae* Gir. were used for right pest at right time. Compared to recommended package of practice system in Integrated Pest Management System, role of natural enemies and activity of parasites was higher, which resulted in less number of sprays, reduced input cost with cost benefit of 4.2 percent.

(*Key words:* Integrated Pest Management, recommended package of practices, economic threshold level, sucking pests, bollworms, net profit)

INTRODUCTION

In recent years, cotton growers in Karnataka and elseshere in India, have resorted to the liberal and indiscriminate use of bizarre combination of 'kill-all' insecticides. They spray their cotton with different insecticides either alone or in combination chosen solely, because of their local popularity and availability and 15–20 spray applications are given each season (REDDY, 1987). Over–reliance on chemical practices without regard to the complexities of the agro-ecosystem, has created pollution problems, made some minor pests attaining a major status and led to pest resistance to pesticides (SUNDARAMURTHY & BASU, 1990). Further, it has increased the plant protection cost, resulting in high cost of cotton production. Keeping this in view, the present study was initiated to develop an IPM programme involving the use of safe and effective insecticides integrated with other methods of pest control.

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MATERIAL AND METHODS

The study was conducted for two seasons, at the Agricultural Research Station, Dharwad, Karnataka State, India, using the cotton variety 'Sharada'. An area of 0.2 ha was selected for Integrated Pest Management (IPM) study and it was compared with recommended package of practices. The crop was sown during third week of July during both the seasons by adopting all the recommended cultivation practices. In IPM block (Block A), different components, namely the natural prevalence of the predatory population, application of phosalone 35 EC to check sucking pests and early bollworm control were followed. When the pests crossed the Economic Threshold Level (ETL), the egg parasite, *Trichogramma achae* Gir. at the rate of 2 lakhs/ha (total population 2 or 3 releases) at 8–10 days interval, based on the bollworm egg population were released. In the other block, where the recommended package of practices were followed (Block B), two rounds of systemic insecticides were given for the control of sucking pests. Later five rounds of contact insecticides

were sprayed for bollworm control in which two rounds of synthetic pyrethroids were alternated with three rounds of conventional insecticides. The observations for different pest populations were carried out on 25 randomly selected plants in both blocks which include: (i) recording of sucking pest population (aphid, jassid, thrips and whitefly) (ii) bollworm incidence (damage from 40 days after sowing—DAS); (iii) Egg population of bollworms on the top growing shoot; and (iv) predatory population (coccinellids, spiders and lacewing).

In addition to above, recording of the larval parasites under field conditions was carried out by collecting 30 larvae from each block at weekly intervals. The larvae were brought to the laboratory and reared till adult pest or the parasite emergence and the percentage of parasitization was worked out. Similarly field recovery of the egg parasite, *T. achae* in IPM block was observed by collecting the bollworm eggs on the 4th day after the egg parasite release and the percentage parasitization was worked out based on the emergence of the parasite. Every year, a total number of seven rounds of insecticide sprays alone were given in block B, while in Block A (IPM block), four rounds of contact sprays and three releases of parasites during first season and five rounds of contact sprays and two releases of parasite were made during second season. The population of sucking pests recorded were converted into average populations per plant and the percentage of bollworm damage and egg population of bollworms, average predatory population and field parasitisation in each species of bollworm were calculated. Yield of kapas was also recorded from both the blocks and lastly the cost benefit ratio for each block was worked out per ha basis.

RESULTS AND DISCUSSION

During first season in Integrated Pest Management System (IPM) the aphid population reached Economic Threshold Level (ETL) at 25 days after sowing (DAS) and was well controlled by the *Coccinellid* predator, but to control higher incidence of thrips, which crossed ETL at 46 DAS, one spray of phosalone (Table 1) brought down all the sucking pests under lower level. This was mainly due to the increased activity of three predators viz., coccinellid, lacewing and spiders. The activity of lacewing, *Chrysopa* sp. was maximum during late September and early October. Among the coccinellids, *Menochilus sexmaculatus* was more predominant and among the spiders, *Neoscona theis* and *Marpissa decorate* were abundant. In recommended package of practice system aphids crossed ETL at 25 DAS which was also well controlled by coccinellid predator, but thrips population was high at 39 DAS which necessitated a spray of phosalone. Due to resistance and less activity of predators its resurgence was high under RPP and reached ETL levels at 46 DAS (16.2) and 67 DAS (10.8). Compared to IPM, due to lower activity of predators aphids remained at higher level in RPP (Table 2). Jassid population remained low throughout crop period while whitefly population was negligible in both blocks. Similar observations of predator activity was reported by SHARMA & ADLAKHA (1981). During second season due to higher activity of predators in IPM block (Table 3) aphids remained at a lower level throughout the crop period and reached ETL at 132 DAS. Thrips attained ETL level at 34 and 55 DAS, which necessitated spray of phosalone twice and thereafter at 76 DAS. The resurgence pattern and activity of both thrips and aphids was higher in RPP (Table 4) block. Thrips attained ETL at 34 DAS (18.20) 48 DAS (15.4) and 62 DAS (12.3)

TABLE 1. Data on the populations of cotton sucking pests, bollworm egg population/damage, predators population and natural field parasitization in integrated pest management block (Block A – I Season).

Days after sowing (DAS)	Sucking pests Mean population/leaf				Boll worm incidence (%)	Mean egg population per plant		Mean predator Populations per leaf			Natural field parasitization (%)	
	A	J	T	W		*H*	*E*	C	S	L	*H*	*E*
25	**12.90**	0.48	2.64	—	—	—	—	**1.72**	0.24	—	—	—
32	2.24	0.84	7.58	0.20	—	—	—	0.52	0.28	—	—	—
39	2.64	0.24	**28.70P**	0.08	—	—	—	0.36	0.16	—	—	—
46	2.08	0.68	5.36	0.08	2.29	—	—	0.48	0.20	0.32	—	—
53	10.96	2.04	48.84	—	**22.80P**	0.25	—	1.08	0.32	0.44	36.0	—
60	1.14	0.68	3.80	—	**3.79**	0.62	—	0.44	0.72	1.20	32.0	—
67	2.12	0.36	9.44	—	8.28	0.18	—	1.80	0.56	1.52	36.0	—
74	0.20	0.76	1.56	—	**17.31C**	0.33	0.40	0.56	0.44	1.20	40.0	—
81	0.44	0.68	0.84	—	4.00	0.28	0.77	0.44	0.72	1.00	28.0	12.0
88	1.40	1.24	0.36	—	6.68	0.84	**2.12**	0.48	0.56	0.08	28.0	16.0
95	0.84	0.76	2.40	0.12	9.29	0.40	**1.84T**	0.14	0.32	—	36.0	32.0
102	3.08	1.32	0.52	—	**12.07**	0.68	**1.44T**	0.40	0.44	—	32.0	4.0
109	2.00	0.40	0.80	—	**14.53**	0.20	0.76	—	0.28	—	11.7	40.0
116	0.80	0.68	—	0.30	**16.48P**	0.20	0.64	—	0.32	—	9.0	32.0
123	0.08	—	—	—	7.10	—	0.28	—	0.36	—	—	**4.7**
130	0.20	0.08	0.44	0.28	9.10	0.04	0.24	—	0.12	—	7.1	16.6
137	1.76	0.36	0.44	0.44	**11.30**	0.08	0.16	—	0.20	—	20.0	26.0
144	1.20	—	0.56	0.56	8.33	—	0.16	—	0.32	—	13.3	17.6

A = Aphids, J = Jassids, T = Thrips, W = Whitefly, C = Coccinellid; S = Spiders, L = Lacewing, *H* = *Heliothis armigera*, *E* = *Earias vittella*; P = Phosalone 35 EC, C = Cypermethrin 10 EC, *T* = *Trichogramma* parasite releases;
bold face: Pest population crossing economic threshold level.

TABLE 2. Data on the populations of cotton sucking pests, bollworm egg population / damage, predators population and natural field parasitization in recommended package of practices block (Block B – I Season).

Days After Sowing (DAS)	Sucking pests Mean population/leaf				Boll-worm inci-dence (%)	Mean egg population per plant		Mean predator populations per leaf			Natural field parasitization (per cent)	
	A	J	T	W		*H*	*E*	C	S	K	*H*	*E*
25	**13.80**	0.60	2.45	—	—	—	—	1.60	0.20	—	—	—
32	3.46	1.06	4.20	0.13	—	—	—	0.13	0.06	—	—	—
39	3.26	0.73	5.33	0.13	—	—	—	0.13	0.20	—	—	—
46	4.33	0.86	**16.20**	0.13	8.82	—	—	0.40	0.13	0.26	—	—
53	0.33	0.13	3.13	—	20.40	—	—	0.06	0.20	0.13	10.5	—
60	1.60	0.93	2.20	—	3.60	0.12	—	0.80	0.33	0.46	12.5	—
67	1.46	0.66	10.80	—	1.73	0.26	—	0.73	0.53	1.26	17.6	—
74	—	0.26	1.26	—	**10.93**	0.17	0.12	0.20	0.20	0.46	15.0	—
81	—	0.53	1.80	—	3.60	0.33	0.53	—	0.20	—	11.0	—
88	0.46	0.33	0.60	—	**5.27**	1.00	2.20	—	0.13	—	8.0	—
95	0.20	0.33	0.86	—	5.55	0.06	0.86	0.06	0.13	—	—	9.0
102	3.13	0.40	0.73	—	**10.64**	0.93	1.13	—	0.06	—	4.0	—
109	—	—	0.26	—	4.15	0.40	0.73	—	—	—	—	16.0
116	1.33	—	0.20	—	**8.39**	0.13	0.53	—	—	—	—	9.0
123	0.60	—	0.20	—	5.80	0.06	0.26	—	0.06	—	—	—
130	0.13	0.06	0.20	0.06	7.10	—	—	—	—	—	—	—
137	4.20	—	0.40	0.20	9.80	—	—	—	—	—	—	—
144	—	—	0.13	0.33	9.02	—	—	—	—	—	—	—

A = Aphids, J = Jassids, T = Thrips, W = Whitefly, C = Coccinellid, S = Spiders, L = Lacewing.
H = *Heliothis armigera*, *E* = *Earias vittella*.

bold face: Pest population crossing economic threshold level.

TABLE 3. Data on the population of cotton sucking pests, bollworm egg population / damage, predator population and natural field parasitization in integrated pest management block (Block A – II Season).

Days After Sowing (DAS)	Sucking pests				Boll-worm inci-dence (%)	Mean egg population/ plant		Mean predator population/ per leaf			Natural field parasitization (%)	
	Mean population/leaf											
	A	J	T	W		*H*	*E*	C	S	L	*H*	*E*
27	1.68	0.44	1.40	—	—	—	—	0.52	0.28	—	—	—
34	0.88	0.08	**11.76P**	—	—	—	—	0.36	0.12	—	—	—
41	0.80	0.12	9.72	—	—	—	—	0.40	0.24	—	—	—
48	3.72	0.28	9.08	0.32	2.00	—	—	1.04	0.36	—	—	—
55	1.10	1.88	**13.08P**	0.36	4.08	0.12	—	0.86	0.08	0.52	—	—
62	0.88	0.40	3.60	0.15	2.67	0.20	—	0.64	0.36	2.32	8.50	—
69	0.48	1.44	4.35	0.20	1.57	0.30	0.08	0.40	0.28	1.28	13.30	—
76	0.56	2.44	8.60	0.20	4.49	**1.52T**	0.12	0.44	1.16	0.48	11.10	—
83	—	5.52	1.08	0.32	9.73	**0.72T**	0.20	0.56	0.24	0.56	32.00	10.00
90	0.12	4.80	2.56	0.16	**17.63**	0.60	0.12	0.20	0.28	0.52	19.00	16.60
97	—	3.04	5.00	0.40	9.56	0.44	0.12	0.24	0.40	0.44	21.50	15.40
104	—	2.80	1.68	1.20	**22.97C**	0.36	0.48	0.08	0.48	0.20	29.50	21.00
111	—	—	0.36	2.16	8.10	0.08	0.40	0.24	0.40	0.08	13.30	15.40
118	2.80	0.04	0.24	3.32	5.45	0.12	0.32	—	0.28	0.80	16.60	14.30
125	4.40	0.04	0.32	0.56	1.05	0.08	0.12	0.08	0.32	0.04	7.10	10.50
132	**12.48P**	0.16	0.32	0.40	2.60	0.08	0.16	0.16	0.24	—	23.00	29.40
139	4.52	0.30	—	—	1.08	0.08	0.16	0.08	0.08	—	16.60	26.60
146	3.88	—	0.16	—	3.05	0.04	0.08	0.16	0.28	—	16.70	15.40

A = Aphids, J = Jassids, T = Thrips, W = Whitefly, C = Coccinellid, S = Spiders, L = Lacewing, *H* = *Heliothis armigera*, *E* = *Earias vittella*.

P = Phosalone 35 EC, C = Cypermethrin 10 EC, T = *Trichogramma* parasite releases.

bold face: Pest population crossing economic threshold level.

TABLE 4. Data on the population of cotton sucking pests, bollworm egg population/damage, predators population and natural field parasitization in recommended package of practices block (Block B – II Season).

Days after sowing	Sucking pests				Boll-worm inci-dence (%)	Mean egg population/ plant		Mean predator, population/leaf			Natural field parasitization (%)	
	Mean population/leaf											
	A	J	T	W		*H*	*E*	C	S	L	*H*	*E*
27	2.26	0.66	4.60	—	—	—	—	0.60	0.20	—	—	—
34	2.13	0.06	**18.20**	—	—	—	—	0.53	0.20	—	—	—
41	2.33	0.06	8.33	—	—	—	—	0.13	—	—	—	—
48	9.80	0.13	**15.40**	0.33	—	—	—	0.26	0.06	—	—	—
55	1.46	—	5.20	0.13	2.04	0.16	—	0.06	0.20	—	—	—
62	**7.55**	—	**12.30**	0.46	**10.55**	0.33	—	0.40	0.13	1.46	—	—
69	—	—	0.13	—	3.48	0.26	—	0.06	0.13	0.33	9.00	—
76	0.06	—	0.40	0.06	3.37	0.80	—	0.13	—	0.40	—	—
83	—	—	4.06	0.33	8.06	0.60	0.20	0.06	—	0.20	8.00	—
90	—	—	—	0.13	7.10	0.26	—	—	—	0.33	—	—
97	—	—	1.00	—	7.54	0.06	—	0.13	—	0.33	5.80	—
104	0.86	0.06	0.26	0.06	6.56	0.20	0.26	—	0.06	—	—	—
111	1.06	—	6.73	0.13	9.57	0.26	0.60	—	0.13	—	12.50	20.00
118	**11.73**	—	2.06	0.53	9.53	0.20	0.33	—	0.13	—	21.40	13.30
125	4.60	—	0.33	0.13	2.22	—	0.06	—	0.13	—	—	16.60
132	**23.50**	—	—	0.06	1.14	—	—	—	0.13	0.06	14.20	12.5
139	0.40	—	—	0.33	1.26	—	—	—	—	—	—	—
146	0.20	—	—	—	1.04	—	—	—	—	—	—	—

A = Aphids, J = Jassids, T = Thrips, W = Whitefly, C = Coccinellid, S = Spider, L = Lacewing, *H* = *Heliothis armigera*, *E* = *Earias vittella*.

bold face: Pest population crossing economic threshold level.

and high population of aphids were seen at 48 DAS (9.8), 62 DAS (7.6) and crossed ETL at 118 DAS (11.73) and 132 DAS (23.50). Due to higher activity of predators in IPM, the three major sucking pests were well under control during the crop period whereas, in the RPP block the low activity of predators increased the activity of both thrips and aphids and caused higher carryover population.

During first season, under IPM egg population of *Heliothis* reached maximum level at 88 DAS, whereas in second season it was at 76 DAS (Table 1). *Earias* eggs remained at lower level and showed comparatively higher values at 88 DAS, 95 DAS and 102 DAS during first season and at 104 DAS and 111 DAS during second season. In both years egg population activity was higher from 70 to 100 days and were well controlled due to higher activity of natural parasite population. Release of *T. achae* at the rate of 2 lakhs per ha twice at weekly intervals reduced egg population of both *H. armigera* and *E. vittella*. The establishment of parasite after release indicated directly in the recovery of both parasitised eggs to a maximum of 40 percent and 35 percent respectively (Table 5). Similar results were reported by THONTADARYA & JAIRAO (1978) and PATEL et al. (1980). Further, cyperme thrin spray brought down the infestation level considerably till the end of the crop.

During first season under RPP, *Heliothis* egg population reached maximum level at 88 DAS and 102 DAS and remained at higher level till the end of the crop, but during second season it was highest at 76 DAS reached lowest value at 97 DAS and thereafter remained at consistent level till the end of the crop. *Earias* eggs were higher than that of *Heliothis* at 88 DAS and 102 DAS during first year and at 111 DAS in the second year. Due to lower activity of predator

TABLE 5. Release recovery of *T. achae* on cotton bollworms in IPM block.

Season	Percent parasitisation on eggs of	
	Heliothis armigera	*Erias vittella*
I Season		
88 DAS	22.85	10.30
97 DAS	31.25	15.75
106 DAS	40.00	35.00
Average:	31.37	20.35
II Season		
77 DAS	23.50	—
85 DAS	37.80	10.20
95 DAS	10.20	5.25
104 DAS	4.75	3.50
Average:	19.06	6.32

and parasites and also development of resistance, they remained at higher level even after 120 days and caused damage to later formed fruiting parts. CHITRA (1989) also observed least toxicity of endosulphan to *Heliothis* larvae as compared to synthetic pyrethroids. She observed that deltamethrin had highest adulticide effect followed by fenvalerate, cypermethrin and endosulphan. The adverse effect of synthetic pyerthroids was also reported by AGARWAL et al. (1983).

The eggs and larval instar population that escaped from natural parasitisation caused early outbreak of bollworms in the succeeding crop. During first season, in IPM, bollworm incidence percent reached maximum at 53, 74, 102, 109 and 116 DAS and during second season, it was highest at 90 and 104 DAS (Tables 1, 3). Safer insecticide spray (Table 1) with higher field parasitisation brought down the percent incidence. The parasite, *Apanteles angaleti* was mainly responsible for the major parasitisation of *H. armigera* and was more predominant than other parasite species. Parasite *Rogus aligharensis* was found more active on *E. vittella*. Other parasite species which were quite active were *Campoletis* sp.,

TABLE 6. Correlation coefficients between sucking pests of cotton and their natural enemies both in IPM and RPP Block.

Variable/Season	IPM Block				RPP Block			
	Aphids	Jassids	Thrips	White fly	Aphids	Jassids	Thrips	White fly
Coccinellid								
I Season	—0.673*	0.337	—0.521	—0.508*	—0.278	0.291	—0.331	—0.205
II Season	—0.712*	0.077	—0.444	—0.572*	—0.307	0.352	—0.265	—0.168
Spider								
I Season	—0.215	0.267	—0.191	—8.449	—0.088	0.252	0.297	—0.369
II Season	—0.210	0.194	0.069	—0.067	—0.303	0.361	0.362	—0.017
Lacewing								
I Season	—0.121	0.143	0.051	—0.634*	—0.096	0.328	0.343	—0.208
II Season	—0.323	0.216	0.063	—0.371	—0.019	0.179	0.164	—0.335

*significant at 5 per cent level.

TABLE 7. Correlation coefficients between bollworm incidence and natural parasitisation in IPM and RPP block.

Variable	Season	Bollworm incidence	
		IPM Block	RPP Block
Percent parasitisation of *Heliothis*	I Season	—0.645*	—0.056
	II Season	—0.597*	—0.336
Percent parasitisation of *Earias*	I Season	—0.744*	—0.022
	II Season	—0.805*	—0.122

*Significant at 5 percent level.

Goniopthalmus of *Heliothis* by natural enemies was reported by FLETCHER & THOMAS (1943), SUNDARAMURTHY & BASU (1985) and the effective predation by *Chrysopa carnea* under field conditions in Gujarat was reported by YADAV & PATEL (1987).

During first season, in RPP the bollworm incidence reached ETL at 53, 74, and 102 DAS and during second season, it was at 62, DAS (Tables 2, 4). Spray of monocrotophos and fenvalerate (Tables 2, 4) checked the bollworm incidence. Failure of *Heliothis* larvae to respond positively to various insecticides was attributed to development of resistance (DHINGRA et al., 1988) due to changes in the biochemical ecology of insect system. Increased carboxyl esterases and free fatty acid content (RAMANATH, 1990) of larvae were probably responsible for this significant change in the population found in the southern eco-system of India (SUNDARAMURTHY & BASU, 1990).

Correlation studies during two seasons between cotton sucking pests and predators in IPM indicated that aphids showed negative correlation (-0.673*, 0.712*) with coccinellid and whitefly showed significantly negative correlation with coccinellid (-0.508*-0.572*) and lacewing (-0.634*, 0.371) and all the correlation coefficients in RPP between sucking pests and predator population were not significant (Tables 6, 7).

The cost of cultivation of Rs. 1503 per ha was same for both IPM and RPP blocks (Table 8). The average amount towards plant protection chemicals was Rs. 2552 in RPP and Rs. 1647 in IPM block and the net saving was about Rs. 905. RPP block recorded gross income of Rs. 9128/ha which was 8.2 percent more than that of IPM block. Due to higher investment on insecticides in RPP the net profit was more in IPM block and recorded 4.2 percent higher value (Table 8.)

TABLE 8. Cost economics per hectare for integrated pest management and recommended package of practices blocks.

Sl no.	Factors	Block A Integrated pest management (Rs.)			Block B Recommended package of practices (Rs.)		
		I Season	II Season	Average	I season	II Season	Average
1.	Cost of cultivation (from land preparation to cotton picking)	1473.35	1532.60	1503.00	1473.35	1532.60	1503.00
2.	Treatment applications (insecticide sprays and parasite cost)	1492.52	1801.80	1647.15 (+904.90)	2695.85	2408.25	2552.05
3.	Yield of cotton kapas (kg)	1684.00	1561.00	1622.50	1896.00	1615.00	1755.50 (+ 133.00 kg)
4.	Gross income*	8756.80	8117.20	8437.00	9859.20	8398.00	9128.60 (+ 691.60) (8.2%)
5.	Net profit/income	5790.93	4782.80	5286.85 (+213.30) (4.2%)	5690.00	4457.15	5073.55

*Average price of cotton at Dharwad during February month : Rs. 520/- per quintal.

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Entomon 1991 Vol. 16 No 4 pp. 301 to 303

EFFECT OF HOST LARVAE OF *HELICOVERPA ARMIGERA* HUBNER ON THE PARASITISING ABILITY OF *CAMPOLETIS CHLORIDEAE* UCHIDA[1]

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The larvae of *Helicoverpa armigera* Hubner of different age groups, 0-1 to 9-10 days were exposed to *Campoletis chlorideae* Uchida to find out most preferred host age group for parasitism. Maximum (137) parasitoids emerged from 4-5 day old host larvae with 45.66% parasitism. A significant correlation exists between the age of host larvae and the percent parasitism ($P<0.05$).

(*Key words: Campoletis chlorideae*, host age selection)

INTRODUCTION

The host selection criteria of the parasitic Hymenoptera has been divided into a sequence of five steps: host habitat location, host finding, host acceptance, host suitability (DOUTT, 1959) and host regulation (VINSON, 1975). The oviposition behaviour of a parasitoid is determined by factors like host age, odour, location, size, shape, colour, structure, sound or even movement (DOUTT, 1959; FISHER, 1959) and may involve visual, olfactory and chemotactile stimulii (VINSON & LEWIS, 1965; CORBET, 1971).

The work on parasitism in relation to host age has been attempted by LEONG & OATMAN (1968) on *Campoplex haywardi* Blanchard, LINGREN *et al.* (1970) on *Campoletis perdistictus* (Viereck), SCHMIDT (1974) on *C. sonorensis* (Cameron) and NIKAM *et al.* (1990) on *Eriborus argenteopilosus* (Cameron).

The present study deals with the host selection behaviour of *C. chlorideae* towards most preferred age of its host *H. armigera.*

MATERIAL AND METHODS

The cultures of the host, *H. armigera* and the parasitoid, *C. chlorideae* were maintained in the laboratory (24 ± 1°C and 55–60% RH). Sixty healthy, unparasitised larvae of *H. armigera* of different age groups 0–1 to 9–10 days old were exposed to a mated female of *C. chlorideae* in wooden insect rearing cages of the size $30 \times 30 \times 30$ cm for 24 hours. Food in the form of 20% honey and artificial diet (NAGARKATTI & SATHYA PRAKASH, 1974) were provided to the parasitoid and host respectively. After 24 hour exposure host larvae were kept separately and host/parasitoid emergence was recorded. Each host age group was replicated five times and each replicate consisted of sixty larvae.

RESULTS AND DISCUSSION

There are significant differences in parasitism with different host age groups. The number of parasitoids emerged were 20, 22, 23, 52, 137, 46, 28, 9 and 4 from 0–1, 1–2,

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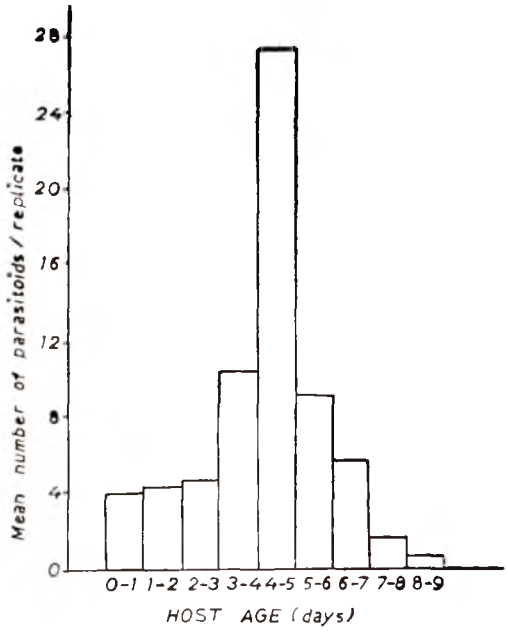

Fig. 1. Maximum effective age of *H. armigera* larvae for parasitization by *C. chlorideae*.

TABLE 1. Maximum effective age of *H. armigera* larvae for parasitisation by *C. chlorideae*.

Host age in days	Percent parasitoid emergence	Parasitoid ratio	
		Male	Female
0– 1	6.66	6.0	4.0
1– 2	7.33	6.3	3.7
2– 3	7.66	5.6	4.4
3– 4	17.33	6.5	3.5
4– 5	45.66	5.8	4.2
5– 6	15.30	6.3	3.7
6– 7	9.30	6.4	3.6
7– 8	3.00	6.6	3.4
8– 9	1.30	5.0	5.0
9–10	0.00	0.0	0.0

2–3, 3–4, 4–5, 5–6, 6–7, 7–8, and 8–9 days host age groups respectively. But no parasitoids emerged from 9–10 days old larvae. Mean number of parasitoids emerged per replicate was 4.00, 4.40, 4.60, 10.40, 27.40, 9.20, 5.60, 1.80 and 0.80 from 0–1, 1–2, 2–3, 3–4, 4–5, 5–6, 6–7, 7–8, and 8–9 days host age groups respectively (Fig 1). Maximum parasitism (45.66%) was with 4–5 days old larvae and mean number of parasitoids emerged was 137. Thus, 4–5 day old larvae are most suitable for maximum parasitism. However, there was no significant difference between the parasitism of 0–1, 1–2 and 2-3 days old larval groups, while 7–8 and 8–9 days old larval groups were least parasitised (Table 1). There exists a significant ($P < 0.05$) correlation eenbetw host age group and the percent parasitism ($r = -0.2483$).

LEONG & OATMAN (1968) subjected *Phthorimaea operculella* Zeller larvae to *C. haywardi* and obtained highest number of adults. Studies of LINGREN *et al.* (1970) deal with preference by *C. perdistinctus* towards *Pseudaletia unipuncta* (Hawarth), *Trichoplusia ni* (Hubner), *Prodenia eridania* (Cramer) and *P. praefica* Grote. 1–8 day old larvae of all hosts were susceptible for parasitism, 2–6 day old being most acceptable. *C. sonorensis* prefers most 3–5 day old larvae of *Heliothis zea* Boddie (SCHMIDT, 1974), whereas in the present findings *C. chlorideae* accepts most 4–5 day old larvae of *H. armigera* with 45.66% parasitism. Similarly, *E. argenteopilosus* also attacks 4–5 day old *H. armigera* larvae with 21% maximum parasitism (NIKAM *et al.*, 1990)

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Entomon 1991 Vol. **16** No. 4 pp. 305 to 309

TWO NEW *CRISTICAUDUS* (HYMENOPTERA: APHIDIIDAE) AS PARASITES OF APHIDS IN GARHWAL RANGE OF WESTERN HIMALAYA, INDIA

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Two new species of *Cristicaudus* viz., *C. indicus* and *C. garhwalensis* are described from Garhwal range of western Himalaya, India.

(*Key words:* new aphidiid parasitoids, *Cristicaudus indicus*, *Cristicaudus garhwalensis*, Garhwal Himalaya, India)

Thirty-five species of aphidiid parasitoids under 11 genera are known from the Garhwal range of Western Himalaya (Das & Chakarabarti, in Press). Further studies on these parasitoids reveal the existence of two new species of *Cristicaudus* from this area and these are described in this paper. This genus is so far known by two species including *C. nepalensis* (Takada) which is also known from Indian subcontinent (Stary & Ghosh, 1983).

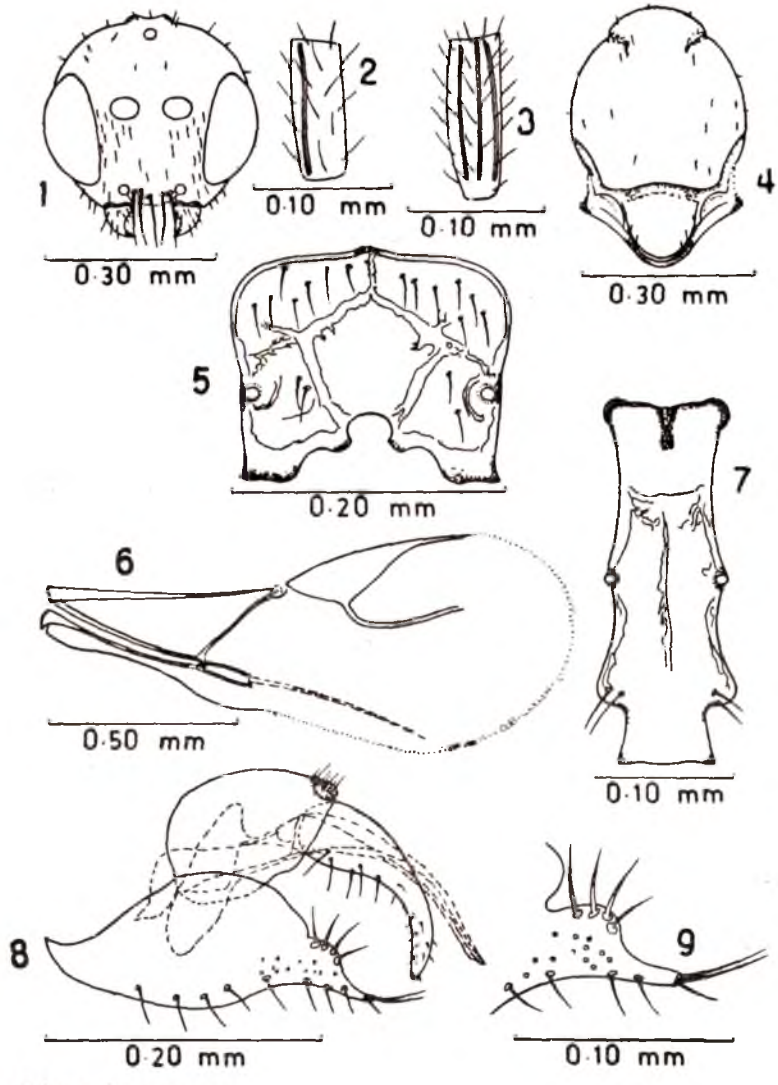
1. **Cristicaudus indicus** sp. nov. (Figures 1-9)

Female: Head (Fig. 1) transverse, smooth, shiny, sparsely haired; face with very sparse hairs; longitudinal eye, length $4.34 \pm 0.88 \times$ width of gena; tentorial index 0.45 ± 0.07; interocular line subequal to facial line, $1.61 \pm 0.15 \times$ transfacial line; transverse eye diameter $1.50 \pm 0.21 \times$ temple; clypeus with 4–5 long hairs. Antennae 11 segmented, reaching to the end of tergite 2 or upto middle of tergite 3; F_1 (Fig. 2) shorter than the length of F_2 (Fig. 3); length of F_1 $2.82 \pm 0.40 \times$ width at base; length of F_2 $5.33 \pm 0.54 \times$ width at base; F_1 with 1 and F_2 with 2–3 rhinaria.

Mesoscutum of mesonotum (Fig. 4) with sparse hairs on disc; notaulices distinct and sculptured, somewhat extended. Scutellum rather wide, smooth, 3–6 hairs on the margin. Propodeum (Fig. 5) areolated, with wide central areola; carinae of areolation wavy and with many accessory carinae; upper areola with 5–9 and lower with 2–3 medium hairs.

Pterostigma of forewing (Fig. 6) triangular length $2.80 \pm 0.11 \times$ width, $1.88 \pm 0.29 \times$ length of metacarp; length of radial vein subequal to the length of pterostigma.

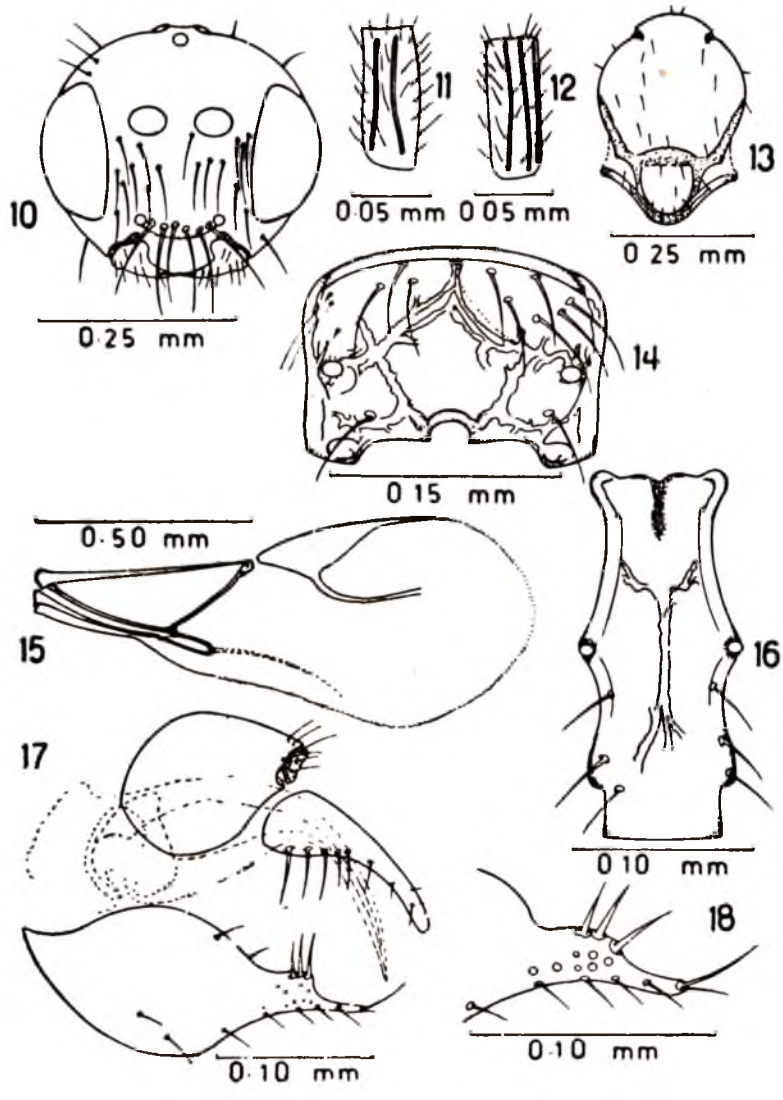
Length of tergite 1 (Fig. 7) $3.10 \pm 0.16 \times$ width across spiracles; distance across spiracles almost subequal or equal (or shorter) to the distance between primary and secondary tubercles; dorsal surface rugose, with one central longitudinal carina; primary and secondary tubercles prominent latterally; lower portion with 4–6 short hairs. Ovipositor sheaths (Fig. 8) strongly narrowed to the apex, strongly curved downwards, with several long hairs on the basal inner side and shorter hairs on the upper and lower side in the apical portion,



Figs. 1-9: *Cristicaudus indicus* sp. nov. Female: 1. Head; 2. First flagellar segment; 3. Second flagellar segment; 4. Mesonotum; 5. Propodeum; 6. Forewing; 7. Tergite 1; 8. Genitalia; 9. Tip of the prong.

maximum length $3.15 \pm 0.27 \times$ maximum width; basal portion of the prong strong, heavily built, bears 4 stiff hairs. Apical part of the prong narrowed, hairless and somewhat curved upwards to the apex; tip of the prongs (Fig. 9) with two long hairs, lower side of the prong with several short stiff hairs; ovipositor lanceolate.

Colouration: Head dirty brown; face deep brown; mouthparts yellowish except deep brown to yellowish brown mandibles; scape yellowish orange, pedicel and basal portion of F_1 yellowish, rest of flagellar portion brown; thorax dirty brown to deep brown except blackish brown mesonotum and mesopleuron; legs yellowish brown to



Figs. 10–18: *Cristicaudus garhwalensis* sp. nov.: Female : 10. Head; 11. First flagellar segment; 12. Second flagellar segment; 13. Mesonotum; 14. Propodeum; 15. Forewing; 16. Tergite 1; 17 Genitalia; 18. Tip of the prong.

yellowish orange except dark brown apices of tarsi; wing veins brown to colourless; tergite 1 deep brown to dirty yellowish brown; ovipositor sheaths and prongs brown rest of the abdomen dirty brown to yellowish.

Measurements of one female in mm: Body length 2.16, Head: Tentorio-ocular line 0.04, intertentorial line 0.08, interocular line 0.33, facial line 0.32, transfacial line 0.19, width of gena 0.05, longitudinal eye diameter 0.19, transverse eye diameter 0.17, temple 0.10, length of antennae 1.34, lenth of F_1 0.10, width of F_1 at base 0.04, length of F_2 0.11, width of F_2 at base 0.02. Forewing : Length of pterostigma 0.33, width of pterostigma 0.12,

length of metacarp 0.16, length of radial vein 0.33. Tergite 1: Length 0.26, width across spiracles 0.08, distance between two tubercles 0.08. Ovipositor sheaths : Maximum length 0.15, maximum width 0.05.

Male: Antennae 13 segmented, body length 1.52 ± 0.15 mm, F_1 with 2–3 and F_2 with 2.–4 rhinaria, colouration generally darker than the female, otherwise like the female except sexual differences.

Mummy of host : Blackish brown.

Holotype : ♀ : INDIA : UTTAR PRADESH Garhwal, Link (*c* 1875 m), *ex Aphis* sp. on *Glochidion velutinum* Wight., 25.vi.1984 (coll. B.C. Das) **Paratypes** : 1 female and 1 male, collection data as in the holotype.

Remarks

C. nepalensis (Takada, 1970), *C. garhwalensis* sp. nov. and *C. indicus* sp. nov. belong to the same species group because of heavily built prongs characterized by strong basal portion with 3–4 stiff dorsal hairs. *C. indicus* differs from *C. nepalensis* by the shape of the ovipositor sheaths and two hairs on the tip of the prongs (in *nepalensis* ovipositor sheaths curved weakly downwards and the tip of the prongs bear one long hair) and from *C. garhwalensis* by the characters of tergite 1. The other species of the genus, *C. bicolor* Stary & Remaudiere (1982) resembles the new species only in having two hairs on the tip of the prongs, but in all other characters the two species are different.

2. Cristicaudus garhwalensis sp. nov.
(Figures 10–18)

Female :

Head (Fig. 10) somewhat round, smooth, shiny, sparsely haired; face with long hairs; longitudinal eye length 4.85 ± 0.10 × width of gena; tentorial index 0.42 ± 0.06; interocular line subequal to facial line, 1.32 ± 0.04 × transfacial line; transverse eye diameter 1.45 ± 0.05 × temple; clypeus with 4–7 long hairs. Antennae 11 segmented, reaching to the end of tergite 2; F_1 (Fig. 11) subequal to length of F_2 (Fig. 12); length of F_1 2.95 ± 0.10 × width at base; length of F_2 2.09 ± 0.26 × width at base; F_1 with 1–2 and F_2 with 2–4 rhinaria.

Mesoscutum of mesonotum (Fig. 13) with sparse, comparatively long hairs almost in two longitudinal rows on disc; notaulices wide, deeply crenulated at the ascendent part, effaced on disc; surface overall rugose. Scutellum rather narrow, smooth with a few comparatively long hairs on disc. Propodeum (Fig. 14) areolated, central areola wide; carinae of areolation very much wavy and with numerous accessory carinae; surface overall rugose; upper areola with 4–7 and lower with 0–3 long hairs.

Pterostigma of forewing (Fig. 15) triangular, length 2.85 ± 0.15 × width, 1.97 ± 0.05 × metacarp; length of radial vein subequal to length of pterostigma.

Length of tergite 1 (Fig. 16) 2.25 ± 0.08 × width across spiracles; distance across spiracles 1.30 ± 0.05 × distance between primary and secondary tubercles; surface somewhat smooth with one prominent central longitudinal carina : hind portion with 4–7 medium hairs. Base of ovipositor sheaths (Fig. 17) somewhat rectangular, narrowed to the apex, slightly curved downwards, with several long hairs on the basal inner side and short hairs on the upper and lower side in the apical portion; maximum length 2.68 ± 0.11 × maximum width; prongs basally strong; heavily built and bear 3–4 stiff hairs, apical part of prongs narrow, hairless and somewhat straight; tip of the prong (Fig. 18) with 1 long hair; several short stiff hairs on lower side.

Colouration :

Head brown; face light brown; mouthparts yellowish except brown apices of mandibles; scape, pedicel and F_1 yellowish; rest of the flagellar segment brown, mesonotum and mesopleuron brown, pronotum and propleuron light brown, propodeum yellowish brown, rest of the thoracic portion brown to light brownish; legs yellowish, except dark brown apices of tarsi and pretarsi; wing veins brown to colourless; from tergite 2 to before last abdominal segment brown, rest of abdomen yellowish.

Measurements of one female in mm :

Body length 1.91. Head : Tentorio-ocular line 0.03, intertentorial line 0.07, interocular line 0.23, facial line 0.23, transfacial line 0.17, width of gena 0.04, longitudinal eye diameter 0.19, transverse eye diameter 0.14, temple 0.10, length of antennae 1.07, length of F_1 0.09, width of F_1 at base 0.03, length of F_2 0.09, width of F_2 at base 0.03. Forewing : Length of pterostigma 0.28, width of pterostigma 0.10, length of metacarp 0.14, length of radial vein 0.28. Tergite 1 : Length 0.21, width across spiracles 0.09, distance between two tubercles 0.07. Ovipositor sheaths : Maximum length 0.13, maximum width 0.05.

Male :

Antennae 13 segmented, body length 1.32 mm, colouration generally darker than the female, otherwise like the female except sexual difference.

Mummy of host : Yellowish brown.

Holotype : ♀ : INDIA : UTTAR PRADESH Garhwal, Joshimath (*c* 1875 m), *ex. Capitophorus formosartemisiae* (Takahashi) on *Artemisia vestita* Wall., 27.ix.1983 (coll. B. C. Das).

Paratypes : 1 female and 1 male, collection data as in the holotype.

Remarks :

The species differs from *C. nepalensis* (Takada, 1970) by the characters of tergite 1 and host range (in *nepalensis* distance across spiracles of tergite 1 subequal to equal or shorter than the distance between primary and secondary tubercles). The relationship of the species with *indicus* sp. nov. has already been given.

The type material of the new species are presently deposited in the collection of Biosystematics Research Unit, Department of Zoology, University of Kalyani Kalyani-741 235, India.

ACKNOWLEDGEMENTS

The authors express their deep sense of gratitude to Dr. P. STARY, Institute of Entomology, Czechoslovak Academy of Sciences, Czechoslovakia for comments on the species and to the Head, Department of Zoology, University of Kalyani, for providing laboratory facilities.

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Entomon 1991 Vol. 16 No. 4 pp. 311 to 315

ON THE WHITEFLIES OF THE GENUS *RHACHISPHORA* QUAINTANCE AND BAKER (ALEYRODIDAE: HOMOPTERA) FROM INDIA

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(*Received* 12 *August* 1990)

Two new aleyrodids viz., *Rhachisphora indica* sp. nov. from unidentified plant and *R. ixorae* sp. nov. from *Ixora* sp. have been described. A key to Indian species of *Rhachisphora* has been furnished.

(*Key words: Rhachisphora indica, Rhachisphora ixorae, Rhachisphora trilobitoides, Ixora* sp.)

The genus *Rhachisphora* Quaintance & Baker is represented in India by a single species namely *R. trilobitoides* (Quaintance & Baker). Other two new species, one from an unidentified plant and the other from *Ixora* sp. are described in detail. In addition a workable key to Indian species of *Rhachisphora* is given.

1. **Rhachisphora indica sp. nov.**

(Figures 1–4)

Pupal case: Black with little wax on dorsum; top shaped, broadest along the thoracic region; found singly on the upper surface near the mid vein only; 0.98–1.19 mm long and 0.99–1.20 mm wide.

Margin: Smooth, deeply indented in the thoracic and caudal pore regions, anterior and posterior marginal setae each 15 μm long.

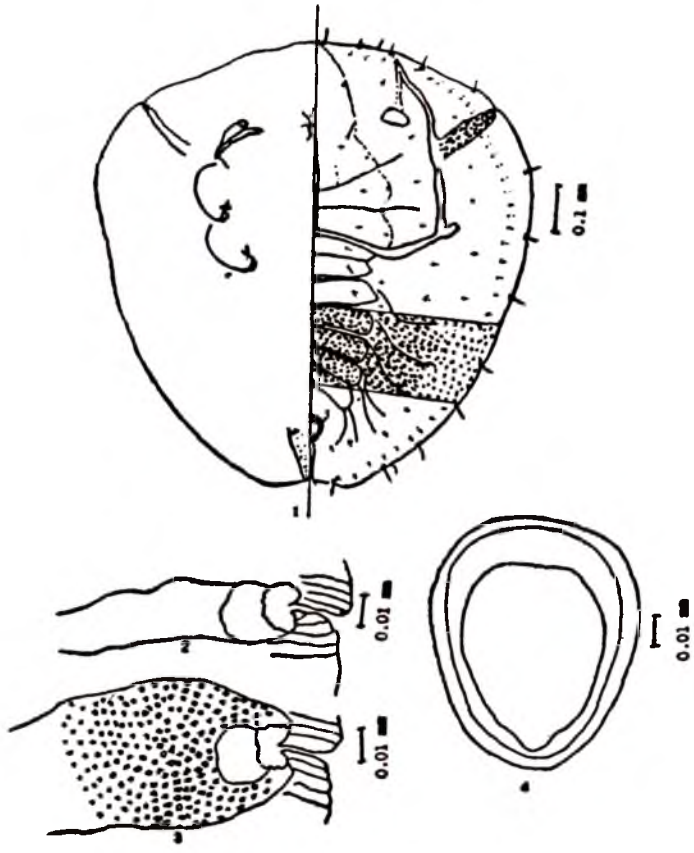
Dorsal surface: Dorsum with three pairs of setae—cephalic setae 15 μm long, eighth abdominal setae, cephalad of vasiform orifice 45μm long and caudal setae 7.5 μm long. First abdominal setae absent. Dorsum with prominent ridges, the ridges are covered with fine polygonal dark areas and the submarginal area and the space between the ridges are covered with irregular rows of semicircular dark markings. Submedian area of the prothoracic and abdominal segments with polygonal markings. The ridges from the metathoracic segment is short without polygonal markings. Submarginal area armed with 13 pairs of spines, each 20 μm long. Submargin with a row of oval shaped pores, subdorsum with three rows of pores and porettes and submedian area with two rows of pores and porettes. Eye spots distinct.

Vasiform orifice: cordate 70–85μm long and 65–80 μm wide, its rim well chitinised. Operculum similarly shaped 50–52.5 μm long and 42.5–45 μm wide. Caudal and thoracic tracheal furrows distinct with polygonal markings.

Ventral surface: Ventral abdominal setae invisible. Tracheal folds distinct without stipples.

Host: Unidentified plant.

Material examined: **Holotype**: INDIA: TAMIL NADU: Munchirai; Unidentified plant, 6.viii. 1987, Coll. R. Sunderaraj. **Paratypes**: six pupal cases on slides bearing the same details.



Rhachisphora indica sp. nov; Fig. 1. Pupal case; Figs. 2 and 3. Thoracic tracheal folds; Fig. 4. Vasiform orifice.

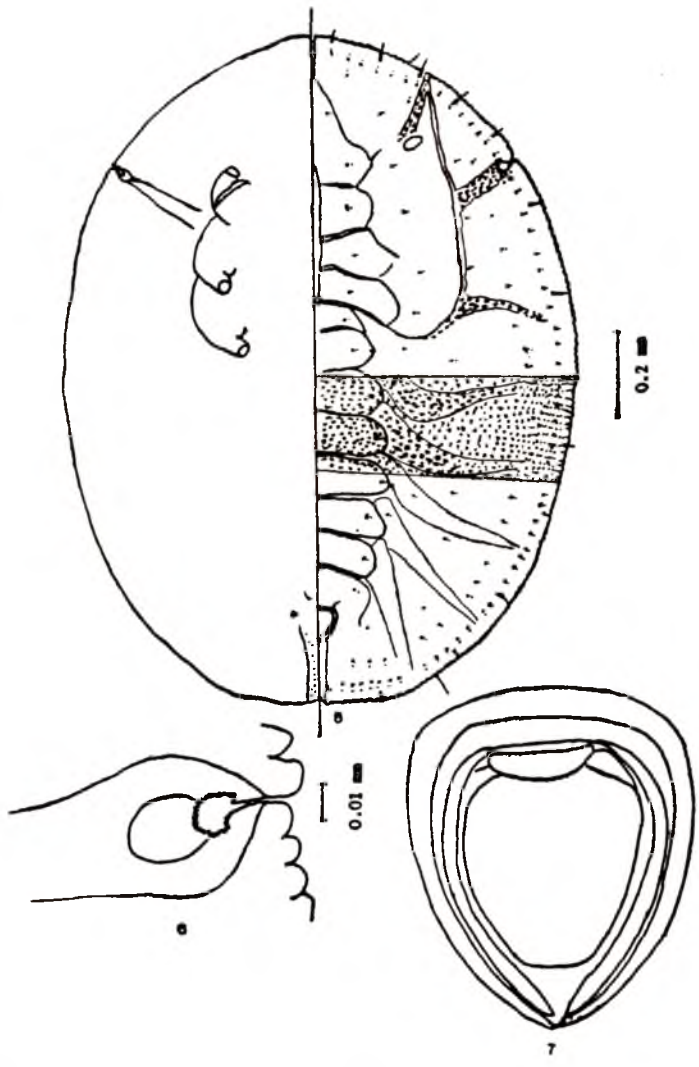
Deposited in: The United States Department of Agriculture, Maryland, U.S.A., British Museum (Natural History), London; Division of Entomology, Indian Agricultural Research Institute, New Delhi, India and the Zoological Survey of India.

This species resembles *R. trilobitoides* (Quaintance & Baker) in shape and size but differs from it in having smooth margin; ridge from the metathoracic segment being short and without polygonal markings, and by the absence of polygonal markings on meso- and metathoracic segments.

2. Rhachisphora ixorae sp. nov.
(Figures 5–7)

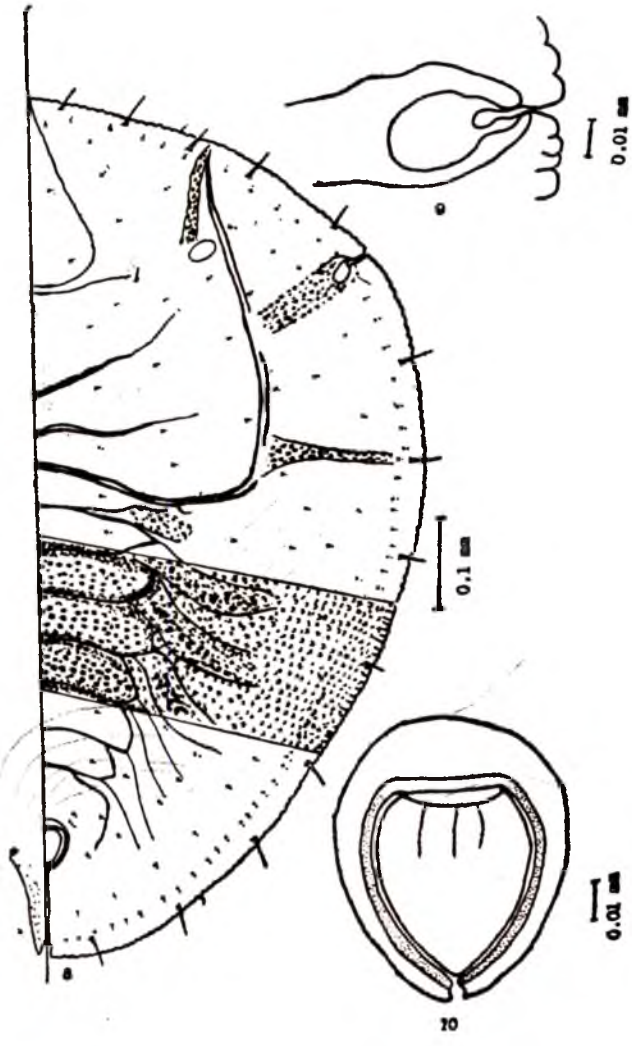
Pupal case: Black with little wax; elliptical, widest along the second abdominal segment region; found singly near the veins on both surfaces more on upper surface; length 1.11–1.56 mm and width 0.80–1.21 mm.

Margin : Regularly crenulate, 12 crenulations in 0.1 mm, deeply indented in the thoracic and caudal tracheal pore regions; anterior and posterior marginal setae each 12.5μm long.



Rhachisphora ixorae sp. nov. Fig. 5. Pupal case; Fig. 6. Thoracic tracheal fold; Fig 7. Vasiform orifice.

Dorsal surface: Dorsum with three pairs of setae—cephalic setae 37.5 μm long, eighth abdominal setae 45 μm long and caudal setae 30 μm long. Setae on first abdominal segment absent. Dorsum with numerous prominent ridges. The ridges are covered with polygonal markings and the submarginal area and the spaces between the ridges are covered with regular rows of semicircular markings. Submedian area of abdominal and thoracic segments also with polygonal markings. Submarginal area armed with 13 pairs of spines each 30 μm long– 5 pairs an terior to thoracic tracheal pores and remaining pairs posterior to it. Submargin with two rows of oval shaped pores, subdorsum and submedian area with two rows of pores and porettes. Eye spots distinct.



Rhachisphora trilobitoides (Quaintance & Baker)
Fig. 8. Pupal case; Fig. 9. Thoracic tracheal fold; Fig. 10. Vasiform orifice.

Vasiform orifice: cordate, 80–105μm long and 67.5–95 μm wide with inner ridges on its lateral and posterior side; operculum similarly shaped 50–57.5 μm long and 45–52.5 μm wide, obscuring the lingula. Thoracic and caudal tracheal furrows distinct with polygonal markings.

Ventral surface: Paired ventral abdominal setae 42.5 μm long and 75 μm apart, thoracic and caudal tracheal folds distinct.

Host: Ixora sp.

Material examined : **Holotype** : INDIA: TAMIL NADU : Kayarambedu; *Ixora* sp., 6. iii. 1971, Coll. B. V. David, **Paratypes:** nine pupal cases on slides, bearing the above details.

Deposited in : The United States Department of Agriculture, Maryland, U.S.A; British Museum (Natural History), London;

Division onf Entomology, Indian Agricultural Research Institute, New Delhi, India and the Zoological Survey of India, Calcutta, India.

This species is close to *R. trilobitoides* (Quaintance & Baker) by the presence of ridge with polygonal markings radiating from metathorax but differs in shape and by the absence of first abdominal setae.

3. Rhachisphora trilobitoides (Quaintance & Baker) (Figures 8–10)

Dialeurodes (Rhachisphora) trilobitoides Quaintance & Baker, 1917. *Proc. U.S. natn. Mus.*, **51**: 433.

Dialeurodes trilobitoides Quaintance & Baker Singh, 1931, *Mem. Dept. Agric. India, Ent. Ser.* **12:** 28.

Rhachisphora trilobotoides (Quaintance & & Baker), Takahashi, 1952, *Mushi*, **24:** 22.

Quaintance & Baker (1917) described this species for the first time and Singh (1931) added detailed notes to the original description. However, the species is illustrated.

Hosts: *Cordia myxa* Roxb., *Eugenia jambos* Linn. (Singh, 1931); *Mimusops hexandra* Roxb. (Rao, 1958); *Randia (Xeromphis) malabarica* Lamk. (Daivd & Subramaniam, 1976); *Mimusops elangi* Linn., *Strychnos nux-vomica* Linn. (new host records).

Distribution: Pusa (Bihar) (Singh, 1931); Hyderabad (Andhra Pradesh) (Rao, 1958); Madras (David & Subramaniam, 1976); Munchirai and Kallar (Tamil Nadu), New Delhi (new distribution records).

Material examined: Eight mounted pupal cases, INDIA : New Delhi : *Eugenia* sp., 21. i. 1967, Coll, B. V. David; ten pupal cases, INDIA: TAMIL NADU: Kallar: *Strychnose nux-vomica*, 20. vi. 1985, Coll B. V. Daivd seven pupal cases, INDIA: TAMIL-NADU : Munchirai: *Mimusops elangi*, 9. viii. 1987, Coll. R. Sundararaj.

KEY TO INDIAN SPECIES OF *RHACHISPHORA* QUAINTANCE & BAKER

1. Pupal case top shaped, broadest across the thoracic region; metathoracic segment without polygonal markings..... 2

–. Pupal case elliptical, broadest across the second abdominal segment region; metathoracic segment with polygonal markings..... .....*ixorae* sp. nov.

2. Margin crenulate; ridge from the metathoracic segment short and with polygonal markings; first abdominal setae present..... .....*trilobitoides* (Quaintance & Baker)

–. Margin smooth; ridge from the metathoracic segment short and without polygonal markings; first abdominal setae wanting..... .....*indica* sp. nov.

ACKNOWLEDGEMENT

Thanks are due to Mr. JAMES FREDRICK, Chairman, Dr. V.R. CHANDRAN, Additional Director and Dr. CLEMENT PETER, Head, Department of Entomology, Fredrick Institute of Plant Protection and Toxicology Padappai, for the facilities provided. It forms part of the Ph.D. thesis of the first author approved by the University of Madras.

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Entomon 1991 Vol. 16 No. 4 pp. 317 to 318

ON A NEW SPECIES OF *SETALEYRODES* TAKAHASHI (ALEYRODIDAE : HOMOPTERA) FROM INDIA

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(*Received* 12 *August* 1990)

A new species *Setaleyrodes litseae* from Shillong (Meghalaya) is described and illustrated.

(*Key words*: *Setaleyrodes*, Aleyrodidae)

Three species of *Setaleyrodes* Takahashi, viz., *S. mirabilis* Takahashi from Japan and Taiwan, *S. auericicola* Takahashi from Taiwan, and *S. takahashia* Singh from Burma are known (Mound & Halsey, 1978). In 1981 David added one more new species namely *S. thretaonai* from India which forms the first report of this genus from this country. In the present paper a new species of the genus *Setaleyrodes* collected at Shillong is described and illustrated.

Setaleyrodes litseae sp. nov.
(Figs. 1–3)

Pupal case: White, without wax, elongate, measuring 0.75 – 0.87 mm long and 0.31–0.35 mm wide; found singly on the under surface of leaves, one or two per leaf.

Margin: Crenulate, 10 crenulations in 0.1 mm; anterior marginal setae indistinct, posterior marginal setae 22.5 μm long; thoracic pores, combs not indicated and caudal tracheal end indented.

Dorsal surface: Three pairs of dorsal setae–cephalic setae 10 μm long, first abdominal setae minute 2.5 μm long, and eighth abdominal setae 12.5 μm long. Dorsum granulated, submargin not separated from dorsal disc, a row of submarginal papilla-like structures and 6 pairs of submarginal setae– 3 pairs on cephalic end and 3 pairs on caudal end, 62.5–105 μm long evident. Abdominal segments 1–5 with distinct median tubercles and thoracic and abdominal segments with depressions. Abdominal segment seven shorter than the sixth and eighth.

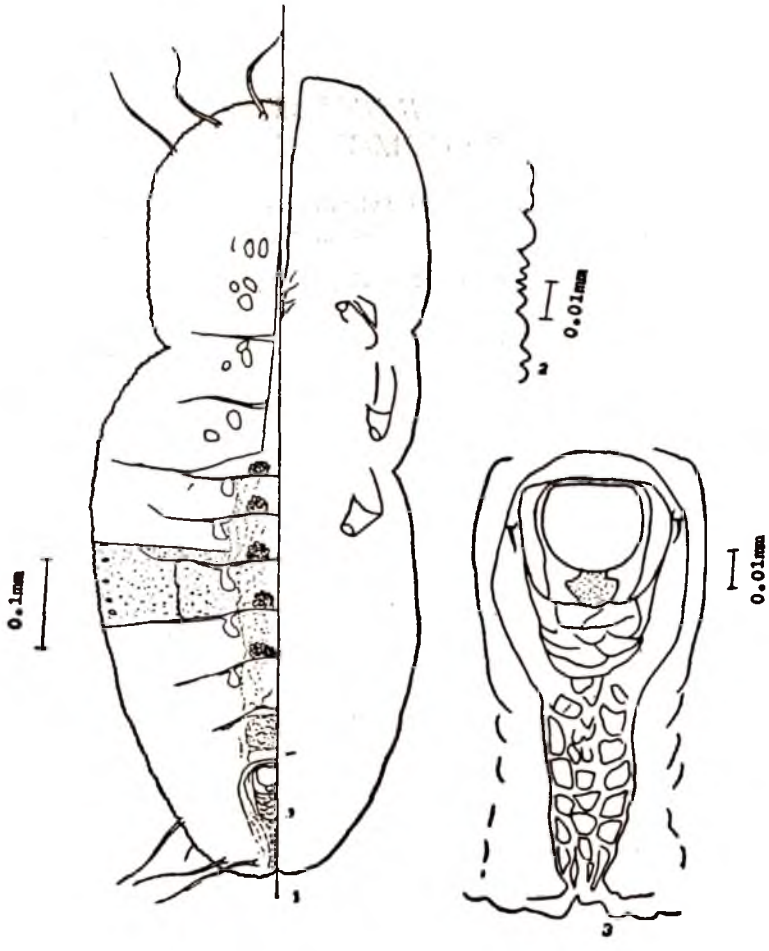
Vasiform orifice : Subquadrate, as long as wide (40 × 40 μm) cephalic margin arched and laterally chitinized. Operculum filling two-thirds of orifice, 20–22.5 μm long and 25–27.5 μm wide. Lingula tip D-shaped, exposed and included. Thoracic tracheal furrows indiscernible, caudal tracheal furrow distinct and sculptured.

Ventral surface : Paired ventral abdominal setae 12.5 μm long and 15 μm apart. A pair of setae at the base of rostrum evident. Antennae short not extending beyond the base of fore-leg. Thoracic and caudal tracheal folds not indicated.

Material examined : **Holotype:** INDIA : MEGHALAYA, Shillong, *Litsea* sp.; 29. ix. 1988; coll. B. V. David.

Paratypes : 5 pupal cases on slides bearing same data as of holotype.

Deposited in: The United States Department of Agriculture, Maryland, U.S.A.; British Museum (Natural History), London; Division of Entomology, Indian Agricultural



Setaleyrodes litseae sp. nov.
Fig. 1. Pupal case (dorsal and ventral surface); Fig. 2. Margin; Fig. 3. Vasiform orifice.

Research Institute, New Delhi, India and Zoological Survey of India, Calcutta, India.

This species differs from the Indian species *S. thretaonai* David by the absence of row of subdorsal setae. However, it runs close to *S. mirabilis* Takahashi (Takahashi, 1951) but differs from it in having only three submarginal setae towards the caudal end and a median tubercle on the first five abdominal segments.

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Entomon 1991 Vol. 16 No. 4 pp. 319 to 322

BRIEF COMMUNICATION

SEM STUDY OF THE STRIDULATORY ORGANS IN THE GIANT DUNG BEETLE *HELIOCOPRIS DOMINUS* (SCARABAEIDAE) WITH OBSERVATIONS ON THE SIGNIFICANCE OF THE SOUND PRODUCTION

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(*Received* 30 *June* 1990)

The SEM study of the striations of the hind coxal cavities and of the hind coxal ridges in the female and male of *H. dominus* made, gives us a better understanding of the mechanism of sound production in *Heliocopris*. The significance of the sound production and of its recognition by both the sexes of this burrowing beetle is explained.

(*Key words*: *Heliocopris dominus*, stridulatory organs, SEM study, significance of sound production)

The functional morphology of the sound-producing organs in the male *Heliocopris bucephalus* Fabr. was studied using light microscope by NARENDRAN & JOSEPH (1978). In this beetle, the dorsal side of the hind coxal ridge has a series of microscopic striations. Similar striations occur on the inside wall of the hind coxal cavities. This striated region of the hind coxal cavity is in contact with the striated region of the hind coxal ridge. During the up and down movement of the hind coxae in their coxal cavities, the striations of the coxal ridges rub against those of the coxal cavities, producing the "wheezing" or "grating" sound.

The present paper deals with the Scanning Electron Microscopic study of the stridulatory organs in the female and male *Heliocopris dominus* Bates and observations on the significance of the sound production.

The stridulatory organs in the female and male of *H. dominus* were carefully dissected out and passed through alcohol series (80%, 90%, 100%) and then transferred into isopropyl alcohol for complete dehydration. The dehydrated male and female organs were mounted on separate stubs, by means of a double adhesive tape. The materials on the two stubs were then coated with gold in the EIKO Gold Coater (Japan). The Coated materials were later scanned with the help of a Table Top SEM (HITACHI 415 A) at 15 KV. The SEM photographic exposures were made on black & white film (size 120).

Examination of materials in the SEM and study of SEM photographs revealed the following:-

Female : (a) *Hind coxal cavity* (Fig. 1). The total striated area (width 2.5 mm) on the inside of the posterior wall of the hind coxal cavity, has about 416 striations. (b) *Ridge of hind coxa* (Fig. 2). The total striated area (width 0.5 mm) of the ridge of the hind coxa has about 112 striations.

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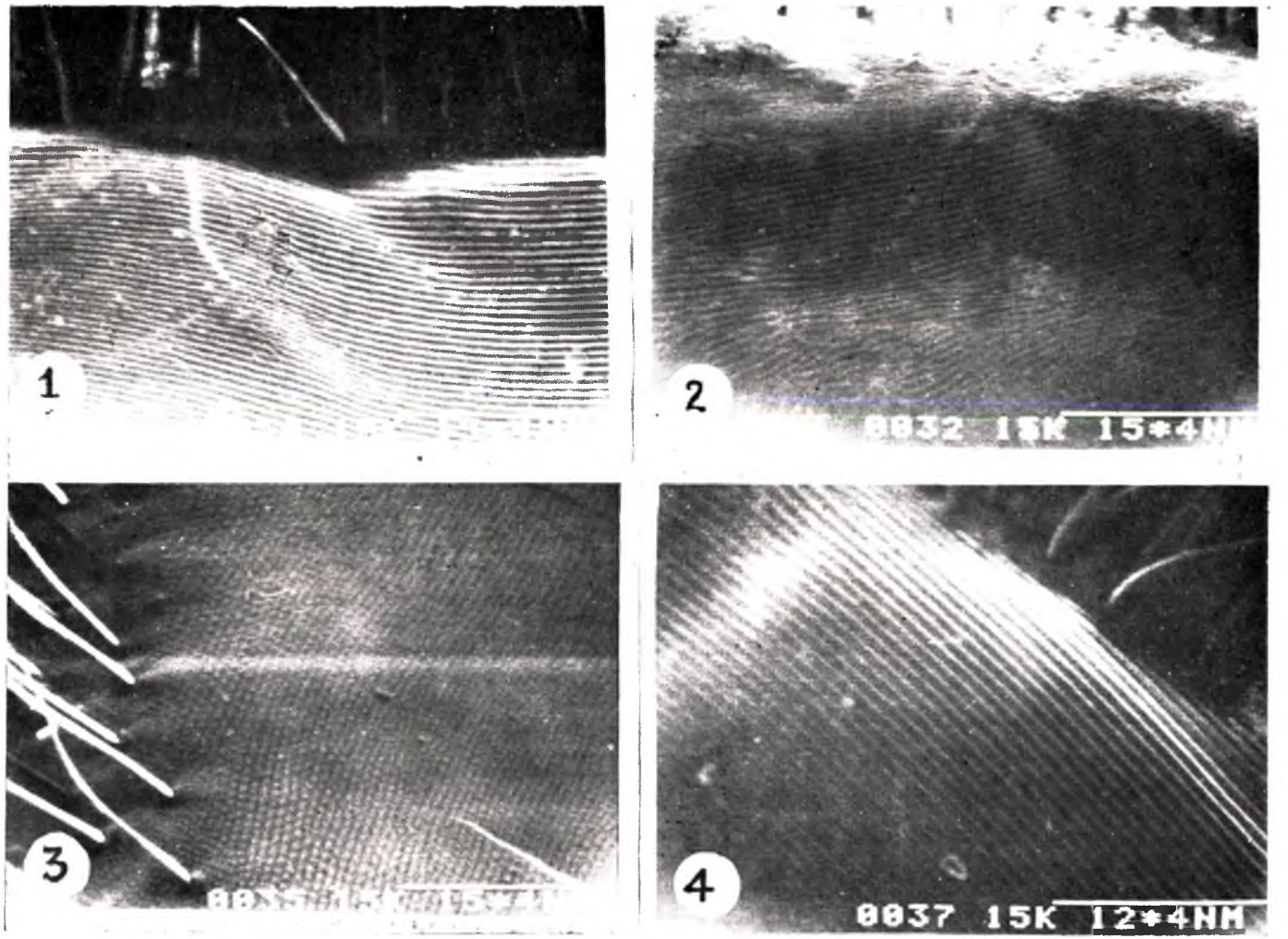

Fig. 1. Inside view of posterior wall of hind coxal cavity of female *H. dominus* showing the striations. Fig. 2. Dorsal view of the ridge of the hind coxa in female *H. dominus* showing the striations. Fig. 3. Inside view of the posterior wall of hind coxal cavity of male *H. dominus* showing: (i) the striations in the region lying deeper in the coxal cavity (region on the right side of the picture) which are more or less continuous and almost similar to those in the female; (ii) the striations in the region lying nearer to the posterior margin of the coxal cavity (on the left side and nearer to the fringe of setae) having their ridges broken up and embossed into button-shaped structures. Fig. 4. Dorsal view of the ridge of hind coxa of male *H. dominus* showing the striations.

Male: (a) *Hind coxal cavity* (Fig. 2). The total striated area (width 3 mm) on the inside of the posterior wall of the hind coxal cavity, has approximately 440 striations. While the striations on the left side of the photograph (region lying deeper in the coxal cavity) are more or less continuous and almost similar to those in the female, the striations on the right side (region lying nearer to the posterior margin of the coxal cavity and near the fringe of setae) are broken up and embossed into button-shaped structures set in rows forming modified striations. (b) *Ridge of hind coxa* (Fig. 4). The total striated area (width 0.5 mm) of the ridge of the hind coxa has about 56 striations.

The female of *Heliocopris* also stridulates. ANNANDALE (1900, quoted from ARROW, 1931) reported that the female of *H. mouhotus* (=*dominus*) is "dumb and incapable of producing sound". ARROW (1931) found that "both the sexes of this species possess an identical apparatus" for sound production. During field work in the Nilambur forests in August 1989, we collected a number of females of *H. dominus* which produced the peculiar wheezing or grating sound. This prompted us to investigate the fine structure of the stridulatory organs in the female also. The present study contributes further proof of the existence in the female of functional stridulatory organs.

The female and the male of *Heliocopris* produce distinct sounds. It was shown above that the morphology, especially the fine structure of the ridges of the striations in the upper region of the posterior wall of the hind coxal cavity in the male differs qualitatively from those present in the same region of the hind coxal cavity of the female. It is therefore reasonable to conclude that the physical qualities of the wheezing or grating sounds produced by the stridulating male and female beetles will be qualitatively different.

KINGSTON & COE (1977) found that the male of *H. dilloni* gains entry into the female's tunnel only after its completion. It is very likely that the male is attracted to the female's tunnel by the sound produced by the female from within her tunnel. Based on observations on *H. dilloni* (KINGSTON & COE, *opt. cit.*), *H. japetus* and *H. hamadryas* (KLEMPERER & BOULTON, 1976) and on the related genus of sub-social dung beetle (*Oniticellus cinctus*, (KLEMPERER, 1983), it can be affirmed that the stimulus for the female to construct the brood chamber and for provisioning it with dung is derived from copulation.

Since the capacity for sonification and its recognition exists in both the sexes of this beetle, it is possible to assume that the female and the male may be able to keep in touch, gauge their relative positions and to co-operate through their auditory method of communication, while engaged in the various stages of brood chamber construction and of provisioning.

The author is grateful to Prof. T. N. ANANTHAKRISHNAN, Dr. A. RAMAN & Mr. NOBLE MORRISON, of the Entomology Research Institute, Madras, for help in carrying out the SEM studies and to the authorities of the College of Horticulture, Trichur, for facilities for work. He thanks the State Committee on Science, Technology & Environment, Kerala, for a Project Grant.

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Entomon 1991 Vol. 16 No. 4 pp. 323 to 325

BRIEF COMMUNICATION

RECORD OF *PTEROLOPHIA GRISEOVARIA* BREUNING AS A PEST ON PEPPER (*PIPER NIGRUM* L.)

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(*Received* 30 *June* 1990)

Pterolophia griseovaria **Breuning (Cerambycidae) infestation on black pepper is being recorded for the first time in India.**

(*Key words*: *Pterolophia griseovaria*, black pepper, first record)

A serious insect pest of black pepper (*Piper nigrum* L.) was noticed during the past few years in the pepper growing tracts of Kerala. It is a longicorn beetle, and is 15-20 mm in length. The adult lays eggs singly on the stem of black pepper and they hatch out inside the stem. The emerging grubs are apodous and creamy white in colour. They have a swollen anterior end with a prognathous, sclerotised brownish head.

The grubs of the beetle hatch out during October-November and start feeding on the internal contents of the stem. Extensive tunnelling of the shoots is done by the grubs, as a result of which, the leaves start yellowing and the vines dry up. The larva completes four larval instars within the tunnel and when fully grown, is 10 to 15 mm long. They pupate inside the larval tunnels and the adults emerge within a week.

Except for drying up of the vines, the plants do not show other external symptoms such as extrusion of frass, and hence, the role of insect is not easily recognised. The symptoms of infestation can be confused with that of the 'Foot rot' disease of pepper, but if the drying of vines is during summer months, the infestation by cerambycid beetles can be suspected. When the plants are infested by these insects, the plants dry up with the leaves in tact on them, while in the case of Foot rot disease, they fall off. A longitudinal splitting of the stem will cause the frass to fall out and the grubs can be seen inside the tunnels.

The longicorn beetles infesting pepper were identified as *Pterolophia griseovaria* Breuning and *Diboma procera* Pascoe (Lamiinae : Cerambycidae). Attack by these insects was widespread in Kasargod and Cannanore Districts of Kerala. About 10-15% of the vines in these tracts dried up due to the attack. They have also been recorded from Kottayam, Idukki, Calicut and Wynad Districts of Kerala as also the Coorg hills, Karnataka.

Pterolophia tuberculata has been recorded on Teak (*Tectona grandis*) and *P. maculata* on Champaka (*Michelia champaka*) (Beeson, 1941). The genus is generally described as spending most of its life cycle saprophytically. A new species, *P. selengensis* has also been described as developing on thin drying or dead twigs of elm *Ulmus pumila* (Lyamstseva, 1979). In pepper also, though the insect starts its life cycle on live vines and branches, most of its life cycle is com-

Fig 2.
Grubs of *P. arisecovaria* (×2.5)

Fig 1.
Pepper vine showing symptoms of infestation by the vine borers.
At left is healthy vine.

pleted as a saprophyte in the dead vines. The infestation is, nevertheless, serious, and causes drying up of the whole vine or parts of it, depending on the stie of infestation.

P. annulata Chevr. and *Diboma procera* Pascoe have been recorded on pepper (Dubly *et al.*, 1976). Occurrence of *P. griseovaria* is being reported for the first time on pepper. Adults of *P. griseovaria* are brownish with two longitudinal white bands on the thorax. Across the elytra, there are wavy white markings. The antennae are slightly longer than the length of the body.

Thanks are due to Dr. M. L. Cox of the CAB International Institute of Entomology for identifying the insect.

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Entomon 1991 Vol. 16 No. 4 pp. 327 to 329

BRIEF COMMUNICATION

CONTROL OF THE THRIPS *SCIRTOTHRIPS DORSALIS* HOOD ON ROSE

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Studies conducted on the control of the rose thrips *Scirtothrips dorsalis* using seven insecticides at two doses revealed that monocrotophos, quinalphos or phosphamidon could effectively suppress the leaf damage by the pest at 0.05%. In the case of flower bud damage, dimethoate and phosphamidon could control the pest at 0.05% while a higher concentration of 0.1% was necessary for monocrotophos and endosulfan.

(*Key words:* rose, *Scirtothrips dorsalis*, leaf damage, flower bud damage, chemical control)

Scirtothrips dorsalis Hood was reported as a pest of rose by ANANTHAKRISHNAN (1960). The thrips, orange in colour, feed on the sap of tender leaves, flower buds and growing tips resulting in elongated brownish lesions. In serious infestations marginal curling up and severe crinkling of the leaves are seen leading to brittleness of the leaves. Buds when infested fail to open in severe early infestations and exhibit dark coloured lesions on buds and calyx. In mature buds brownish patches are seen on the outer petals. The flowers which bloom after the feeding of the thrips show distorted petals. In severe infestations, the plants appear sickly. As the damage caused to rose plants by the thrips was heavy, a pot culture experiment was conducted using seven insecticides for the control of the pest at the Instructional Farm, Vellayani during 1986.

The insecticides (Tables 1 and 2) were sprayed at 0.05 and 0.1% concentrations. A quantity of 100 ml of spray fluid was applied on each plant using a hand sprayer. Water spray served as control. There were 4 plants per treatment and the treatments were replicated thrice and were arranged in a completely randomised design. In order to assess the percentage of damage caused to the leaves the total number of tender and crinkled leaves were counted. Similarly the total number of flower buds and damaged flower buds were also recorded to assess the damage to the buds. The observations were recorded 7 and 14 days after treatment.

The results (Table 1) indicated that 7 days after application, plants treated with methyl parathion (0.05%) showed least leaf damage 40 percent (4.36) followed by methyl parathion (0.1%), phosphamidon (0.05 and 0.1%), monocrotophos (0.1%) and quinalphos (0.05%), the differences among them being statistically insignificant. Endosulfan at both the doses ranked next with a mean damage of 20 percent (6.68) and 32 percent (6.83) respectively. The remaining treatments were on par with control.

On the 14th day after application, least leaf damage of 10 percent (2.49) was observed in plants treated with dimethoate (0.1%) and this was on par with monocrotophos (0.05 and 0.1%), endosulfan (0.1%) and quinalphos (0.1%). The other treatments were also effective in reducing the damage excepting the lower doses of dimethoate, quinalphos and methyl parathion.

TABLE 1. Extent of damage caused by *S. corsalis* on leaves of rose plants treated with different insecticides at two doses.

Treatments	Pre-treatment population (No. of leaves)	Mean percentage of damage on five tender leaves/plant observed at different intervals after spraying (days)	
		7	14
endosulfan			
0.05%	42	20 (6.68)	44 (6.02)
0.1%	34	32 (6.83)	28 (5.04)
fenthion			
0.05%	70	42 (7.16)	40 (6.05)
0.1%	52	24 (7.17)	42 (6.21)
methyl parathion			
0.05%	38	40 (4.36)	64 (7.54)
0.1%	52	52 (5.13)	42 (5.25)
quinalphos			
0.05%	34	14 (6.13)	60 (6.85)
0.1%	54	26 (7.24)	34 (4.82)
dimethoate			
0.05%	84	42 (8.02)	60 (6.91)
0.1%	76	34 (8.33)	10 (2.49)
monocrotophos			
0.05%	54	16 (7.96)	30 (4.52)
0.1%	46	34 (5.73)	26 (4.16)
phosphamidon			
0.05%	46	36 (5.18)	50 (6.59)
0.1%	48	38 (5.72)	46 (6.38)
Control	52	74 (9.13)	84 (9.42)
CD (at 5% level)		(2.15)	(2.70)

Figures in parentheses are values adjusted for pre-count after $\sqrt{X+1}$ transformation.

In the case of damage caused to flower buds (Table 2) it was seen that 7 days after application, the effect of monocrotophos 0.05% was superior to control. There was no difference among the other treatments.

At 14th day after treatment, the data on flower bud damage showed that dimethoate (0.1%) caused highest reduction in damage to a mean level of 15 percent (8.0) and was on par with monocrotophos (0.1%) and dimethoate (0.05%). Monocrotophos (0.05%), phosphamidon (0.1% and 0.05%), endosulfan (0.1%) and methyl parathion (0.05%) also suppressed the damage to significant levels compared to control. The remaining treatments were not effective in reducing the damage.

Higher doses (0.1%) of dimethoate, monocrotophos and phosphamidon was necessary for the effective suppression of flower bud

TABLE 2. Extent of damage caused by *S. dorsalis* on the flower buds of rose plants treated with different insecticides at two dosages.

Treatments	Pre-treatement population (No. of flower buds)	Mean percentage of damage on flower buds observed at different intervals after spraying (days)	
		7	14
endosulfan			
0.05%	40.0	50.0 (4.59)	75.0 (8.29)
0.1%	54.5	34.8 (6.49)	42.5 (5.18)
fenthion			
0.05%	61.6	54.7 (6.32)	69.9 (8.22)
0.1%	68.2	55.0 (7.15)	74.0 (8.55)
methyl parathion			
0.05%	22.5	21.6 (3.85)	63.5 (6.76)
0.1%	45.0	43.3 (5.36)	84.6 (8.83)
quinalphos			
0.05%	55.0	38.3 (6.01)	70.9 (8.04)
0.1%	91.0	44.6 (9.15)	65.0 (7.73)
dimethoate			
0.05%	42.1	40.0 (5.36)	20.7 (3.41)
0.1%	42.5	7.5 (5.73)	15.0 (8.0)
monocrotophos			
0.05%	35.0	30.0 (3.07)	33.5 (4.55)
0.1%	47.0	10.0 (6.58)	16.0 (2.10)
phosphamidon			
0.05%	40.0	20.0 (5.04)	65.0 (6.78)
0.1%	30.0	19.1 (4.15)	39.2 (4.71)
control	33.3	87.3 (5.87)	87.5 (9.83)
CD (at 5% level)		(2.37)	(2.15)

Figures in parentheses are values adjusted for the pre-count, after $\sqrt{X+1}$ transforation.

damage caused by *S. dorsalis*. This might be due to the concealed nature of the insects which remain inside the unopened flower buds, for the control of which an insecticide with translocation properties will be more effective. Regarding the other species of thrips, spraying with HCH 0.1%, dimethoate 0.03%, methyl demeton 0.025% or parathion 0.025% was found to control *Retithrips syriacus* (ANANTHAKRISHNAN, 1973) and lindane 0.1% and DDT 0.2% were found effective against *Rhipiphorothrips cruentatus* (PAL, 1966).

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Entomon 1991 Vol. 16 No. 4 pp. 331 to 333

BRIEF COMMUNICATION

IDENTIFICATION OF SEX IN THE LARVAL AND PUPAL STAGES OF *AILANTHUS* DEFOLIATOR, *ELIGMA NARCISSUS INDICA* ROTH. (LEPIDOPTERA: NOCTUIDAE)

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(*Received* 12 *April* 1991)

Sex determination of the larvae of *E. narcissus indica* is based on the characteristic paired pits at the abdominal end of female. Reliable criteria for sexing pupa are size and location of genital opening and the ratio of distance between genital and anal openings.

(*Key words:* larval and pupal sexing, *Ailanthus* defoliator, *Eligma narcissus indica* Roth.)

The major monophagous pest of *Ailanthus* in Kerala, as elsewhere in India, is *Eligma narcissus indica* Roth. (Lepidoptera: Noctuidae) (VARMA, 1986). The various life-history stages of the species have been briefly described and illustrated by ROONWAL (1982). The larvae cause serious damage by feeding and defoliating young and mature leaves. While studying the morphogenetic processes of this insect, we felt the need for an accurate and quick method for sexing larvae and pupae. Earlier, larval sexing had been attempted in a few lepidopterous insect species wherein, characteristic dark spot(s), pits and cuticular depression in either of the sex have been taken as useful criteria. Pupal sexing has been reported earlier in a number of lepidopterous insects based on various morphological and morphometric characters.

Eggs of *E. narcissus indica* were collected from the field. The larvae on hatching were transferred to rearing bottles and were maintained on leaves of *A. triphysa* at ambient temperature 23–32°C, 75–90% RH and 12:12 LD approximately. Leaves were changed every day. Two hundred larvae and 150 pupae were studied for sexual identity. Field collected individuals were also studied for comparison.

Measurements of the whole pupae were made on millimeter scale while the size of genital and anal pores and the distance between these were studied using a binocular dissection microscope fitted with an ocular micrometer.

There are six larval instars. Both sexes are of the same size. Sex of the larvae could be established by microscopic examinations, from the 4th instar onwards. In the female, there were two paired pits situated on small white spots on the ventrolateral surface of the 8th and 9th abdominal segments which are absent in the males (Fig. 1). These pits are always symmetrical with regard to the antero-posterior axis of the body and located in between two characteristic bristles. Larval sexing by similar criteria has been reported in a number of lepidopterous insects such as *Lymantria dispar, Pyrrhartia isabella, Paramyelois transitella, Pachytelia unicolor* and *Ostrinia nubilalis* (LAVENSEAU, 1982). In all these species, the paired pits are present either on the 8th or 8th and 9th abdominal segments of female larva. However in the castor semiloper, *Achoea janata* the paired pits are present on the 11th and 12th abdominal segments (ANNIE-JOHN & MURALEEDHARAN, 1989).

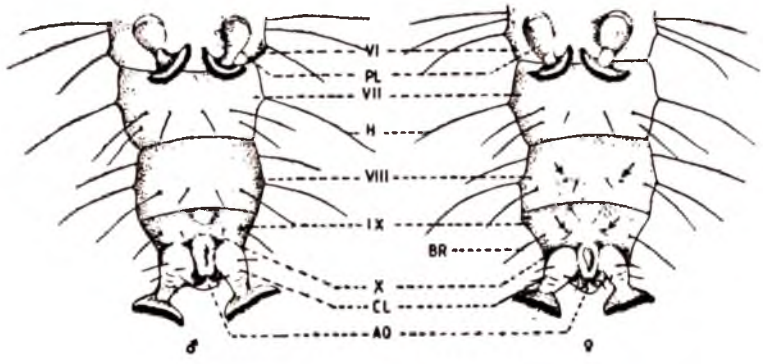

Fig. 1. Ventral view of posterior end of abdomen of *E. narcissus indica* larva. Paired pits on a white base (indicated by arrows) are present in the female while in the male there are no pits.

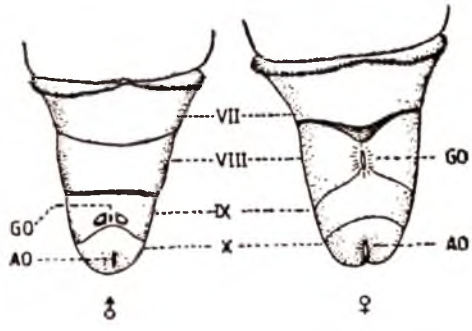

Fig. 2. Ventral view of 7th to 10th abdominal segments of the pupae of *E. narcissus indica*; AO — Anal opening; BR—Bristle; CL — Clasper; GO-Genital opening; H — Hair; PL — Pro-leg.

Abdominal wriggling of pupae was observed in both sexes, while male showed more frequent and active abdominal movement. Male pupae were comparatively smaller in size than female (Table 1) and this gives a fair degree of accuracy in sexing laboratory reared insects. However, in a heterogenous population of pupae collected from the field, especially when those from different localities were pooled together, this criterion was not useful. The size and weight of the pupae were also found to vary.

TABLE 1. Morphometric variations in male and female pupae of *Eligma narcissus indica*

Characters*	Pupae	
	Male	Female
Total length	21.875 ± 0.797	24.050 ± 0.626
Abdominal length (post wing pads)	8.864 ± 0.368	7.780 ± 0.547
Abdominal width (4th segment)	6.720 ± 0.330	7.735 ± 0.300
Length of genital opening	0.289 ± 0.025	0.570 ± 0.039
Length of anal opening	0.931 ± 0.047	0.970 ± 0.045
Distance between genital and anal openings	0.883 ± 0.065	1.755 ± 0.125
Pupal weight (on 1 day, in gram)	0.436 ± 0.049	0.584 ± 0.029

* Measurement in mm ± SD (Mean of 20 observations)

The size and location of the genital opening and the relative distance between genital and anal openings were found to be the most reliable criteria for sexing the pupae. The seventh to tenth abdominal segments are almost fused and bears midventrally two openings, the anal and genital (Fig. 2). The narrow slit-like anal opening is of the same size in the pupae of both sexes (Table 1) and is situated on the terminal end of the tenth abdominal segment, surrounded by an area of wrinkled integument, the anal rise. The genital opening is also slit-like in both sexes, but in female pupa its size is almost double as that of the male pupa. Further, in male pupa it lies in between elevated tubercles, one on each side, on the posterior margin of the 9th sternite, just in front of the inter-segmental line between 9th and 10th abdominal segments. In female pupa it lies on the posterior margin of the 8th abdominal segment and lacks elevated pads. The anterior margin of the 9th sternite is pushed forward and the intersegmental line between 8th and 9th abdominal segments does not meet in the middle (Fig. 2). The ratio of distance between genital and anal openings in male and female pupae is about 1:2. Since the elevated tubercles, one on either side of the genital opening in male pupa and the genital opening in female pupa can be easily recognised pupal sexing based on these criteria is easy and practical.

ACKNOWLEDGEMENT

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Entomon 1991 Vol. 16 No. 4 pp. 335 to 336

REPORTS AND NEW RECORDS

NEW RECORD OF *HOMONA PERMUTATA* MEYRICK (TORTRICIDAE : LEPIDOPTERA) ON FRUIT CROPS FROM SOUTH ANDAMAN

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(*Received* 28 *October* 1990)

A leaf folder *Homona permutata*, is reported for the first time as a pest of mango, guava and citrus from South Andaman.

(*Key words*: *Homona permutata*, tortricidae, leaf folder, mango, guava, critus)

Intensive survey is being conducted for recording the insect pests associated with fruit crops in Andaman and Nicobar Group of Islands,. During December–January, 1989 the leaves of mango (*Mangifera indica* L.), guava (*Psidium guajava* L.) and citrus (*Citrus medica* L.) were found folded by the caterpillars of *Homona premutata* Mey. at Garacharma Research Farm in South Andaman. The caterpillar folds the leaves by bringing together its margin, hides and feeds within the fold. It becomes full-grown in 20–25 days and attain 23 to 26 mm length. Pupation is in the leaf fold and adults emerge in 5–7 days. Guava is more damaged than mango and citrus.

The caterpillar is pale green with black head. The prothoracic shield is represented by a thin black line and body is covered by fine hairs. Caterpillar moves briskly when disturbed. Moth is yellowish-brown with 18–22 mm wing expanse, the male being smaller than female. The forewing has a dark brown oblique line near the apical margin/angle and has a faint oval spot at the centre (Fig. 1). This species was originally described from four specimens collected

Fig. 1. *Homona permutata* Meyrick (Tortricidae: Lepidoptera)

in the South Andaman by Ferrar in May–June 1927 at an altitute of 1200 ft (Tuck, 1990). Since then no one has collected this insect. No information is available on its pest status on food plants. However, other species *Homona trachyptera* was reported on mango leaves from Indonesia (Tandan and Verghese, 1985). Other related species known in India are *H. menciana* Wlk. and *H. cofferia* Nietn., which occur mainly on tea but sometimes on jamun and coffee (Das, 1965). *Homona* sp. was also recorded on Cardamom in India (Nair, 1975).

The author is thankful to Dr. A. K. Bandyopadhyay, Director, Central Agricultural Research Institute, Port Blair for

providing facilities to conduct the survey, Dr. K. R. Tuck, British Museum (Natural History), London for identification of insect and Mr. R. P. Dubey for his technical help.

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Entomon 1991 Vol. 16 No. 4 pp. 337

ERRATUM

Omission of Fig. 8 from the article "Taxonomic Studies on *Aphelinus* (Hymenoptera: Aphelinidae). IV. A new and three known species from Nepal" by Mohammad Hayat, which appeared in *ENTOMON* Vol. 16, No. 3, p. 183-186 (1991), is regretted, and is given below.

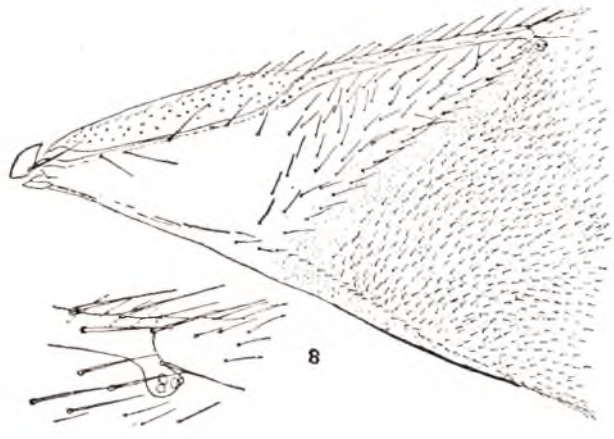

Fig. 8. *Aphelinus nepalensis*, sp, nov., female, part of fore-wing with distal veins enlarged and shown separately, setae on ventral surface of costal cell shown as dots.

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(*Continued from cover page* 1)

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